POWER PLANT ENGINEERING

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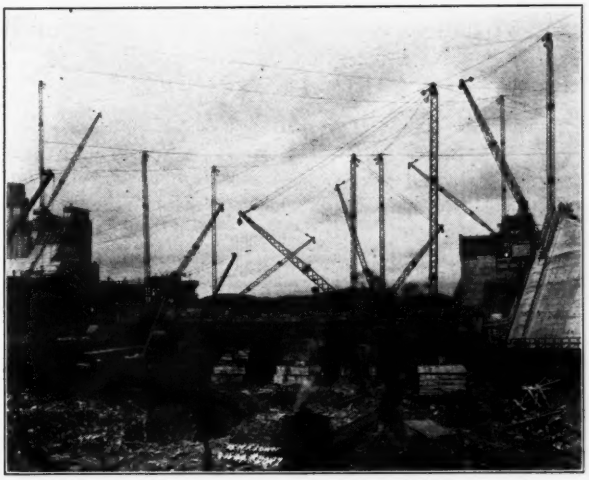


Pyramids

3731 B. C. THOUSANDS of sweating, lash-driven slaves straining in a burning sun, for years. Up with the dawn, struggling to exhaustion to move a block a few feet nearer to its place in an ineffective, useless monument to the grandeur of a selfish ruler, whose identity has been lost in uncertainty for centuries. 1931 A. D. A dinky switch engine, spider-webs of steel, spun on swinging branches, a dozen men, pulling a few levers. In a few months rises a pyramid to ease the toil of thousands. Perhaps this builders name will also be lost in uncertainty in future years but the power he has built up at 15-Mile Falls (the plant is described in other columns of this issue), will flow on, to benefit mankind.

Another splendid example of how power can be controlled for the benefit of mankind is the great system of power plants and distribution equipment that serves New York City. Elsewhere in this issue will be found a detailed analysis of the load conditions of that system, showing how at every turn the operators of the system are governed by the needs and activities of the millions of people it serves.

Those who decry the conditions in this age of power may well look back into history. But we whose effort thus makes for greater production and less need for work may well consider how in the future these can best be applied for the welfare and happiness of the mass of human workers. Unemployed leisure is no satisfactory substitute for contented toil. Forced labor is slavery but productive employment, sufficient to yield comfortable subsistence, is essential to human freedom. The old pyramids stand as symbols of useless slavery. The new ones should be symbols of freedom.

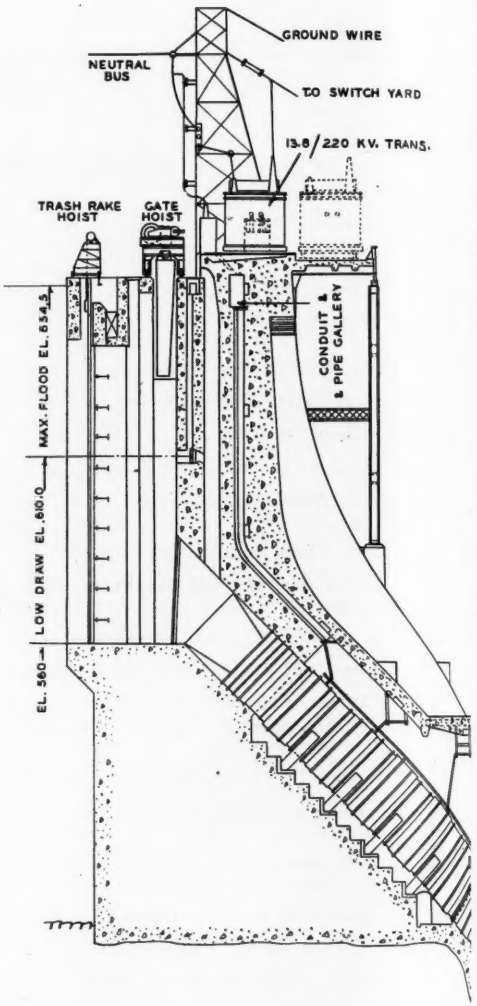
FIFTEEN-MILE FALLS

New England Power Association's Connecticut River project includes Lower Development providing 156,000 kv.-a., McIndoes Falls 13,200 kv.-a. plant with two Kaplan and two fixed blade propeller runners and first 220 kv. transmission lines in New England.

AT FIFTEEN-MILE FALLS on the Connecticut River in Munroe, N. H., and Barnet, Vt., the New England Power Association is carrying out one of the largest hydroelectric developments in the country. In a stretch of the river 20 mi. long through which it drops 320 ft. (most of this drop being in 15 mi., hence the name), it is proposed to develop about 350,000 hp. This is to be done by two large dams, one at lower Fifteen-Mile Falls, completed last September, one at Upper Fifteen-Mile Falls not yet constructed and a smaller dam 7 mi. downstream from lower Fifteen-Mile Falls at McIndoes Falls, completed and put in service in March. The dam at the Lower Development is 175 ft. high and the smaller, at McIndoes Falls, which assists in regulating the flow, is 30 ft. high. At Lower Fifteen-Mile Falls, the installed generating capacity is 156,000 kv-a; and the McIndoes Falls plant has a total generator capacity of 13,200 kv-a.

The completion of two parts of this great hydroelectric development makes available to New England about 170,000 kv-a., which is distributed through the New England Power Association's system and its various interconnections. The 220-kv. transmission line 126 mi. long, running from Fifteen-Mile Falls Lower Development, terminates at Tewksbury, Mass. At Tewksbury a substation has been built to control the distribution of this power not only to The Edison Electric Illuminating Co. of Boston but also to the substation at Pratt's Junction where it feeds into the main portion of the New England Power Co.'s system.

This tremendous power site at Fifteen-Mile Falls, where the river drops 320 ft. in 15 mi. as noted above, has had a romantic



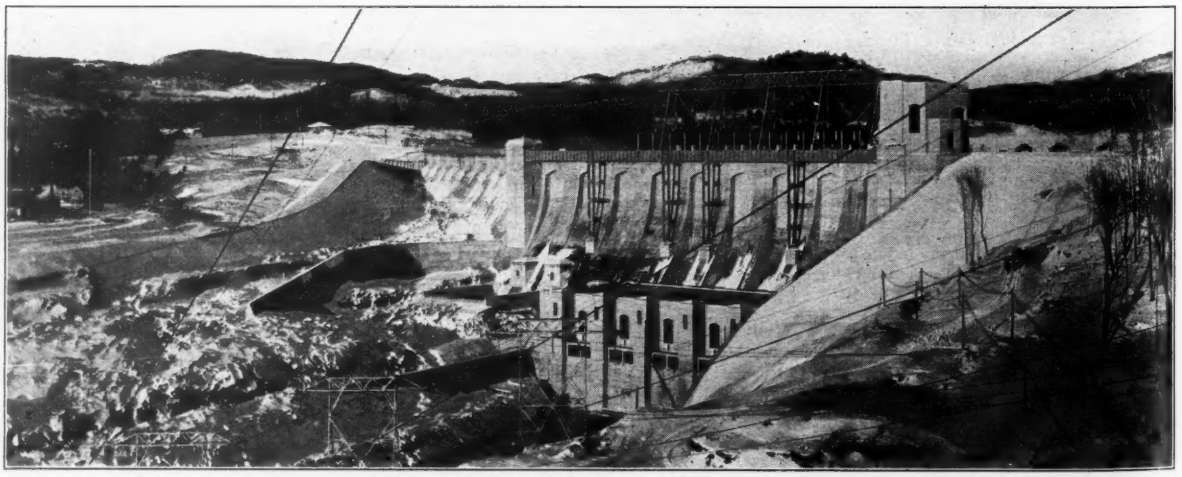


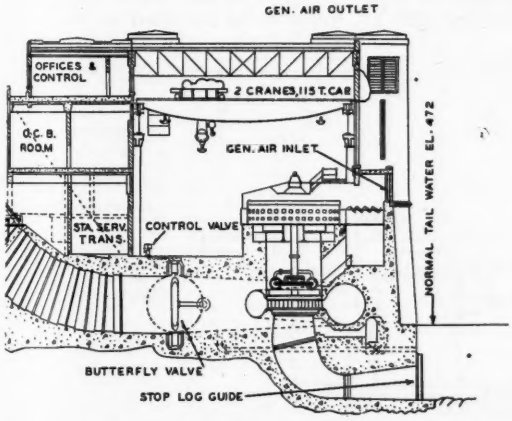
FIG. 1. GENERAL VIEW OF FIFTEEN-MILE FALLS LOWER DEVELOPMENT, SHOWING POWER HOUSE, DAM, SPILLWAY AND TRANSFORMER PLATFORM

history. In the days of the big lumbering operations on the Connecticut River, 20 yr. ago, this stretch of swift water was famous among the log drivers. Here there were jams and delays, races for right of way, often battles between rival forces.

Development of the power resources at this point was studied by engineers for many years but it was not until 1928 that a definite decision was made by the New England Power Association to carry out the project. Construction work was begun in August, 1928, and 25 mo. later, at 10:30 a.m. on the morning of September 30, 1930, Herbert Hoover, President of the United States, pressed a button in Washington that placed in operation the first generating unit at the Lower Development. On March 12, 1931, the first generating unit at McIndoes Falls, 7 mi. downstream, began operation.

Carrying out this work at the Lower Development involved 1,480,000 cu. yd. of excavation, placing of 361,300 cu. yd. of concrete, construction of dykes for which 320,000 cu. yd. of earth were placed, erection of 5,000 t. of structural steel and many other items. At the peak of the construction work, about 2500 men were employed, for whom a construction camp was built at East Barnet.

At the McIndoes Falls development, the work included excavation of 5,000 cu. yd. of earth, 23,000 cu. ft. of rock, placing of 17,000 cu. yd. of concrete and 10,000 cu. yd. of fill. While the work was in progress at the Lower Development, the transmission line and



substations at Franklin, N. H., and Tewksbury, Mass., were being built. Construction schedule for the job, showing how closely the actual work followed it, is shown in Fig. 3. The entire development is to be operated by the Grafton Power Co., part of New England Power Association.

Fifteen-Mile Falls Lower Development

The Lower Development, like most other hydro-electric plants, consists essentially of a non-overflow dam, spillway section, intake and control works, power house and switching equipment. General arrangement of these elements is shown in Fig. 1. Starting on the Vermont side, from a 295 ft. abutment section, the spillway section, 850 ft. long, is built on a ledge of rock. This section is a concrete structure from 30 to 100 ft. high, its downstream face shaped for proper water flow over it without cavitation and its top surmounted by 291 ft. of 6 ft pin type flash boards and 509 ft. of 8 ft. stanchion type

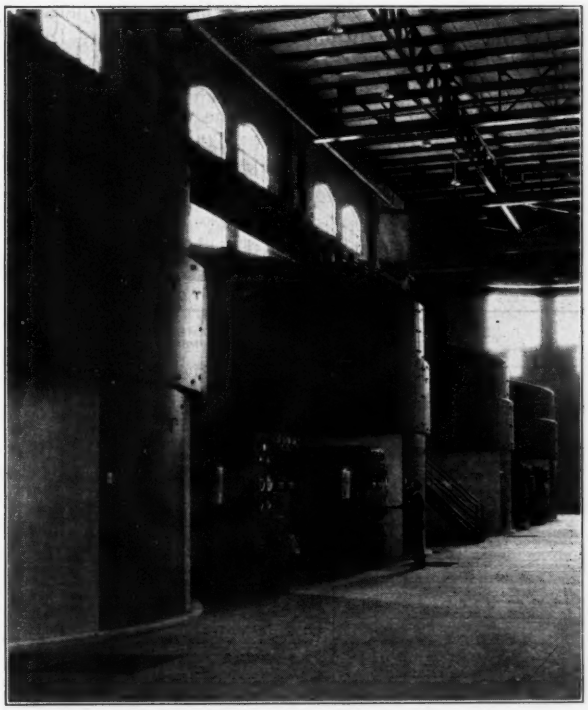


FIG. 2. FOUR 39,000-KV-A GENERATORS AT LOWER DEVELOPMENT

flashboards. Six low pressure sluices, closed by 7 by 9-ft. hydraulically-operated sluice gates, pass through the lower part of this spillway section. Concrete piers 5 ft. thick and 77 ft. 9 in. on centers along the spillway support the bridge leading to the transformer platform and service house.

Intake structure and power house occupy the bed of the river; the space between them and the spillway section is filled by a concrete non-overflow dam section, while on the New Hampshire side an earth embankment held by concrete retaining walls forms the remainder of the non-overflow section.

Intake Structure

The intake structure serves, of course, the double purpose of intake and dam. It is of solid concrete, its top 182 ft. 6 in. above the center line of the water wheels, with buttresses 20 ft. wide spaced 45 ft. center to center. In four of the spaces between these buttresses lie the penstocks, as shown in the headpiece. Each penstock is 19 ft. in diameter, of plate steel construction, reducing to 16 ft. at the turn where it enters the power house sub-structure. Trash racks with a mechanical rake and two Broome gates 19 ft. by 29 ft. 10½ in. control the flow of water to the penstocks, with stop log guides between them for unwatering the gate space. The motor-driven gate hoist runs on a track just over the gate slot.

The power house, built on a concrete substructure directly below the intake structure, houses the water wheels, generators and auxiliaries and the equipment for electrical control.

Four Francis type water wheels are installed here, each of 53,750 hp. capacity at 170 ft. head and designed to operate at 138.5 r.p.m. Each water wheel runner is

12 ft. in diameter. Efficiency of the wheels operating under the above conditions is about 92 per cent. In the penstock just ahead of each water wheel, a 16-ft. Dow disc-arm valve, controlled from the generator floor above, serves to shut off the water from the wheel.

Each water wheel drives a 39,000 kv-a., 13,800-v., 3-phase, 60-cycle generator with direct connected exciters, the four units providing 156,000 kv-a at 0.9 power factor and 13,800 v.

Between the generators on the downstream face of the power house, shafts for air inlets and outlets form

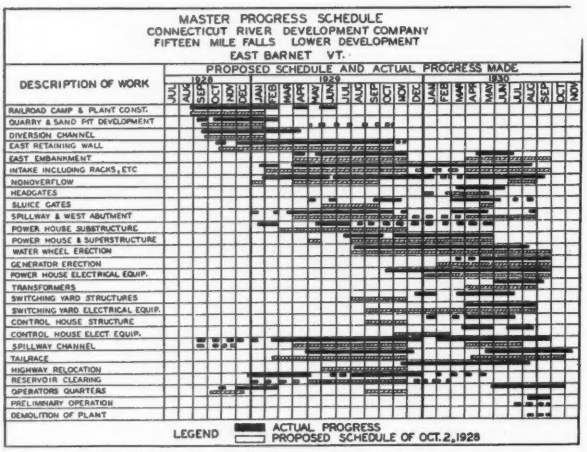


FIG. 3. MASTER PROGRESS SCHEDULE FOR CONSTRUCTION OF LOWER DEVELOPMENT

the most important architectural feature of the power house design. These generators require large quantities of ventilating air and this air is drawn through the downstream wall into the metal enclosure of the generator. From here it can discharge through the shaft, in which two outlets are provided; one leads directly outdoors for summer operation, the other leads the air back into the generator room for heating in winter. In addition, a duct with dampers as shown will permit recirculation of ventilating air in the generator enclosure as desired.

Electrical Equipment

Power for station auxiliaries such as pumps, air compressors, hoists and cranes comes at 460 v. from banks of 13,800/460 v. station service transformers connected to the generator leads and set in bays between the buttresses of the intake. At one end of the room, one of these bays contains a machine shop and at the other is a service bay connecting with the freight elevator to the transformer service station, described later. Governors with pressure oil pumps are located on the generator floor, together with the lubricating oil pump. Two 115 t. cranes in the generator room handle the machinery for maintenance and inspection work.

In the electrical section of the building, the plant control room is on the top floor. Just below this floor are rooms containing the station service 460 v. bus and control boards and 13.8 kv. oil circuit breakers for control of the generating equipment. Below these rooms are the station service transformer bays closed off from the generator room by rolling steel doors. Hatchways in the generator room floor provide access to the penstock valves and valve operating mechanisms.

Switching is done on both sides of the main power transformers, at 13,800 v. in the station and at 220 kv. in the outdoor switchyard. The main transformers were placed on top of the intake where they would have a good foundation. Generator leads run up to them through conduit spaces in the concrete intake. A gallery at the top, just under the transformers, provides access to the conduit pull boxes and is used for oil and water piping. From the transformers the high-tension cables run to the outdoor switchyard on the New Hampshire hillside below the dam.

To provide sufficient space for the transformers, a platform bridge was built along the downstream side of the top of the intake. This bridge also carries the railroad tracks from across the spillway. The transformers can be moved along on this bridge to the transformer service building at the New Hampshire end of the intake.

This building is provided with freight shaft and crane and passenger elevator leading to the generator floor. The bridge is an important item in the scheme as the railroad over this bridge and spillway forms the only passage by which heavy freight can be brought to the plant. The bridge is built to handle all this freight, also assembled transformers filled with oil going into and out of the service building.

Main transformers consist of 14 single phase units, oil-insulated water cooled type, each rated at 13,000 kv-a., to step up the voltage from 13,400 to 230,000. Water for cooling them is taken off the penstocks, circulated by pumps and returned to the intake. These transformers, the first 220 kv. units to be installed in New

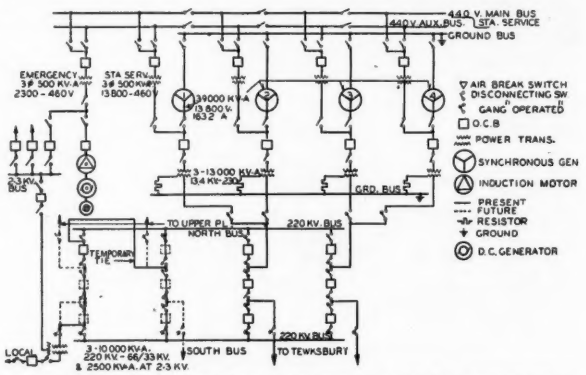


FIG. 4. ONE-LINE WIRING DIAGRAM OF FIFTEEN-MILE FALLS LOWER DEVELOPMENT

England, are of two winding, single-phase, non-resonating, core-type construction, designed to operate in Y on a grounded neutral system. The high-tension winding has four taps at 240, 230, 220 and 210 kv. and is equipped with ratio adjuster operated from ground level. Transformer tanks are of welded steel with bolted top section about two feet high.

Outdoor 220-kv. Switchyard

The outdoor switchyard contains the 230 kv. oil circuit breakers, remote-controlled from the control house located on the north side of the yard, the necessary 220,000 v. disconnecting switches, lightning arresters and other auxiliaries. This yard occupies a space about 550 by 530 ft.

From McIndoes Falls plant downstream, a 66 kv. transmission line, at present operated at 33 kv., leads

to a 12,500 kv-a. transformer in a smaller 66 kv. switchyard near the end of the east embankment. This transformer is wound for 220 kv., 66 kv. and 2.3 kv. and from it a 220 kv. line connects with the main switchyard, thus putting the McIndoes Falls power on the line. Also, a connection from this transformer to the 2.3 kv. bus and then through a 2300/460 v. transformer to the station bus provides an emergency source of auxiliary power.

The power house is built of gray-buff brick to harmonize with the concrete of the dam and intake structure. The railroad bridge and transformer platform are also painted gray to harmonize with the concrete. As the concrete reflects a "cold" light into the power house building, the interior was decorated with buff shades for the walls, ivory white ceiling and red tile floor.

McIndoes Falls Development

McIndoes Falls plant, seven miles downstream from the Fifteen-Mile Falls Lower Development, is designed

Principal Equipment—Fifteen Mile Falls Lower Development

GENERAL

Location—On Connecticut River in Monroe, N. H., and Barnet, Vt.
General Operating Data—Drainage area 1,650 sq. mi.; pond area 1,050 acres; operating pondage 38 ft. draw; 1,330,000,000 cu. ft.; average gross head, 170 ft.
Designers — Engineering Department, New England Power Construction Co.
Construction Work — Connecticut River Development Co. and Fraser-Brace Engineering Co., Inc.
Construction begun—August, 1928.
Plant put in operation—September 30, 1930.

GENERATING EQUIPMENT AND AUXILIARIES

4 S. Morgan Smith Co. 53,750-hp. each, Francis type water wheels, 12 ft. diameter runner, designed for 170 ft. head, 138.5 r.p.m. Kingsbury thrust bearings.
4 Westinghouse Electric & Mfg. Co. 13,800-v., 60-cycle, 3-phase generators, each 39,000 kv-a. with direct connected 250-v., 210-kw. exciters and pilot exciters, 250 v., 25 kw.
4 S. Morgan Smith Co. actuator type hydraulic turbine governors.
4 Quimby Pump Co. governor oil pumps, each 300 g.p.m. driven by 75-hp. General Electric Co. motors.
1 Viking Pump Co. model ZK lubricating oil pump driven by Westinghouse 1½ hp. motor.
2 Allis-Chalmers Mfg. Co. transformer cooling water pumps, capacity 350 g.p.m. each, 150 ft. head, driven by 25-hp. Allis-Chalmers Co. motors.
2 Worthington Pump & Machinery Corp. Axiflo sump pumps, capacity, 1, 150 g.p.m. and 1, 270 g.p.m. at 7½ ft. head. G. E. Motors, 1½ and 5 hp.
1 Ingersoll-Rand Co. 9 in. by 8 in. class E R-1 belt-driven single-stage air compressor, 173 c.f.m., each, 100 lb. pressure driven by 25-hp. Westinghouse Electric & Mfg. Co. motor.
2 Worthington Pump & Machinery Corp. booster pumps—capacity 150 g.p.m. at 405 ft. head, driven by 30-hp. Westinghouse motors.
2 Worthington Pump & Machinery Corp. pumps for low pressure sluices, capacity 150 g.p.m., at 300 lb. pressure, driven by 60-hp. Westinghouse motors.
2 Viking Pump Co. model ZKM pumps for transformer and oil circuit breaker oil—30 g.p.m. at 125 lb. pressure driven by Westinghouse 5-hp. motor.
1 Ingersoll Rand Co. two-stage type 30 air compressor—20 c.f.m. 200 lb. pressure with 5-hp. General Electric motor.
1 Westinghouse Electric & Mfg. Co. spare exciter motor generator set, 210 kw., 250 v., d. c. driven by 325-hp. motor; pilot exciter, 3 kw. 250 v.
Electric Storage Battery Co. storage battery—13-30 amp. for 8 hr.
Rochester Electric Product Corp. diverter-pole generator set, 3½ kw. for charging storage battery.

WATER CONTROL EQUIPMENT

2 Philips & Davies Inc. Broome self-closing intake gates, 19 ft. by 29 ft. 10½ in., each with 120-t. electric traveling hoist.
4 S. Morgan Smith Co. Dow disc arm inlet valves.—16 ft. dia., hydraulically operated.
6 I. P. Morris & DeLaVergne, Inc. low pressure cast-iron sliding gates.
4 Chicago Bridge & Iron Works penstocks, each 19 ft. diameter, 150 ft. long of ⅜-in. to 1⅛-in. steel plate.
2 S. Morgan Smith Co. 9-ft. diameter, Dow disc arm pivot valves, including housing and operating mechanism, for high pressure sluices.
2 Cleveland Crane & Engineering Co. cranes, 115 t.
1 Philips & Davies, Inc. crane—90 t.

MAIN TRANSFORMERS

14 General Electric Co. 13,000-kv-a., single-phase, water-cooled outdoor transformers, 13,400 v./230,000 v.
1 General Electric type W.C.T.-60 12,500-230,000 (G.R.) Y-33,000, Y/66,000, Y//2300 H.D.H. outdoor transformer.

ELECTRICAL EQUIPMENT

4 Generator oil switches, type F-H 206—2000 amp. 15,000 v..General Electric Co.
Disconnecting switches, bus insulators ....Electric Power & Equipment Corp.
Generator and transformer lead..... ....Kerite Insulated Wire & Cable Co.
Switchboard ebony asbestos..... .....Johns-Manville Co.
Instrument and control switch—Type W...Westinghouse Electric & Mfg. Co.
Indicating instruments..... .....Weston Electric Instrument Co.
Temperature recorders ....Leeds & Northrup Co.
Relays..... General Electric Co.
Watthour meters...General Electric Co.
Test switches.....States Co.
Signal device.....General Electric Co.
Automatic switching equipment for controlling 5 station service feeders .....General Electric Co.
High speed rheostatic generator voltage regulator equipment..... ....Westinghouse Electric & Mfg. Co.
Automatic Frequency and Load Control Equipment ....Warren Telechron Clock Co.

STATION SERVICE TRANSFORMERS

4 General Electric 3-phase transformers. Type H.T. 60 cycle, 500 kv-a. 13,800—460 v.
1 General Electric 3-phase transformer. Type H.T. 60 cycle, 500 kv-a. 2300—460 v.

220-KV. SWITCH YARD

7 General Electric oil circuit breakers—230 kv.—800 amp. 3-phase motor-operated, type F.H.K.O.
22 Disconnecting switches—220 kv., 800 amp., 3-phase, motor-operated—Electric Power & Equipment Corp.
1 Disc. switch, 220 kv., 800 amp., 3-phase, hand-operated—Electric Power & Equipment Corp.
Bus copper—Anaconda Wire & Cable Co.
Insulators, grading rings..... .....Locke Insulator Co.
Bus fittings.....Burndy Engineering Co.
1 230-kv., 3-phase Thyrite lightning arrester—General Electric Co.
Control battery EOGO-13—120 cell, 250 v.....Electric Storage Battery Co.
1 Motor generator set—5 kw., 250-v.
Diverter pole..... ....Rochester Electric Products Corp.
Steel for switchyard..... .....American Bridge Co.

TRANSMISSION LINE

2 single circuit, steel tower, 220,000-v. lines, 126 mi. long. 760 mi. Aluminum Co. of America conductor, A.S.C.R., 795,000 c.m.
4 American Steel & Wire Co. ground wires, ½-in. galvanized plow steel.
2254 American Bridge Co. steel towers. Ohio Brass Co. and Locke Co. insulators.
Conductor spacing 23.5 ft. horizontal; circuit spacing 183 ft.

PRINCIPAL EQUIPMENT AT McINDOES FALLS

Location—Connecticut River, 7 mi. down stream from lower 15-Mile Falls.
Operating Data—Drainage area 2,200 sq. mi., pond area 540 acres; operating pondage, 14 ft. draw, 220,000,000 cu. ft., ave. gross head 27 ft.
2 S. Morgan Smith Co. fixed blade propeller type water wheels, each 3500 hp. capacity at 27 ft. head, 150 r.p.m. driving 2 General Electric 3300 kv-a. 2400-v. 60-cycle, 3-phase generators with direct connected exciters and Gibbs thrust bearings.
2 S. Morgan Smith Co., Kaplan water wheels (propeller runners with vanes adjustable by governor) each 4750 hp. at 27 ft. head at 150 r.p.m. driving two General Electric Co. 3300-kv-a., 2400-v., 3-phase 60-cycle generators, with direct-connected exciters and Gibbs thrust bearings.
3 McClintic-Marshall Co. tainter gates.
1 McClintic-Marshall Co. skimmer gate.
4 General Electric Co. single-phase, water-cooled outdoor transformers, each 4400 kv-a. 2400/33,000 v. Power transmitted to Lower 15-mi. Falls over a single-circuit 33-kv. wood pole line designed for later operation at 66 kv.
4 General Electric type FKR-55-24 T.P.S.T., 1200 amp., 7500 v. solenoid operated oil circuit breaker.
1 General Electric Co. type FKR-55-20 T.P.S.T., 400 amp., 7500 v. solenoid operated oil circuit breaker.
1 General Electric Co. type FH-206 T.P.S.T., 4000 amp., 7500 v. solenoid operated oil circuit breaker.
1 General Electric Co. 33 kv.-3-phase Thyrite lightning arrester.
2 Railway Industrial Engineering Corp. type T.T.R. 600 amp., 73-kv., 3-phase disconnecting switch, gang operated.
3 General Electric Co. 100-kv-a. 1-phase 2400-240-v. 60-cycle type O.I.S.C. transformers.
Switchboard complete ....General Electric Co.
1 General Electric Co. 50 kw., 125-v., 900-r.p.m. compound-wound spare exciter driven by a 75 hp. 2300 3-phase 60 cycle induction motor...

PROPOSED UPPER 15-MILE FALLS DEVELOPMENT

Located 8 miles upstream from Lower 15-Mile Falls. Average gross head 149 feet. Proposed capacity, 125,000 kv-a. Reservoir area, 3,500 acres; operating pondage 5,000,000,000 cu. ft. 40 ft. draw; reservoir length 12 mi.; drainage area 1600 sq. mi.

CENTRAL NEW HAMPSHIRE SUBSTATION

4 General Electric Co. 230,000-v. oil circuit breakers with complete control equipment and control house. Provision for step-down transformers when required.

TEWKSBURY SUBSTATION

6 General Electric Co. 230,000-v. oil circuit breakers.
7 General Electric Co. 23,000-kv-a. 220,000/110,000/13,800-v. transformers.
1 Westinghouse Electric & Mfg. Co. 15,000 kv-a., 13,800-v. synchronous condenser.

CONTROL EQUIPMENT, INSTRUMENTS, ETC.

Same makes as at the Lower Development 220-kv. yard.

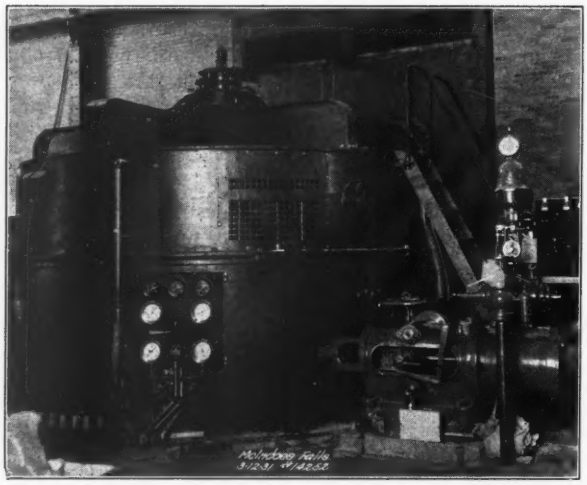


FIG. 5. PROPELLER TYPE WATER WHEELS DRIVE THE FOUR 3300-KV-A. GENERATORS AT McINDOES FALLS

to operate as an integral part of the latter, to utilize the natural fall at McIndoes of about 27 ft. and turn into power the water coming from the larger plant above. Since this amount of water will vary widely, depending on how the larger plant is operating and since the head is low, propeller type water wheels were used here. Two of these are of the automatically adjustable vane type, which provide high efficiency over a wide variation in head, and two are of the fixed blade type; by proper operation of various combinations of these runners, the maximum power can be obtained for a given quantity and head of water made available from the discharge of the plant upstream.

The McIndoes Falls plant consists of a 520 ft. spillway extending from the New Hampshire side of the river to an integral intake and power house in the bed of the river on the Vermont side. The section of the spillway 300 ft. long nearest the New Hampshire shore is equipped with 6-ft. pin type flashboards. Next to this a section contains three 24-ft. Tainter gates and between these and the power house are two sections of 18 ft. stanchion flashboards (each 50 ft. long) and a 12 ft. skimmer gate.

The power house contains four single-runner propeller type water turbines, two with fixed blades and two with vanes adjustable from the governor mechanism as noted above. The four turbines have a total rating of 16,500 hp. at 27 ft. head, 150 r.p.m. They drive 3300-kv-a., 2400-v. 60-cycle three-phase generators with direct connected exciters. These units have combined guide and thrust bearings and are mounted on steel pedestals.

Outdoors, on a shelf on the downstream side of the station, four water cooled 4400 kv-a. transformers step up the voltage to 33 kv. for transmission to the Fifteen-Mile Falls switchyard. As noted, transformers and transmission line are designed for later operation at 66 kv.

First 220-kv. Transmission Line in New England

Transmission line connecting the Fifteen-Mile Falls development, with the Tewksbury, Mass., substation consists of two single-circuit 220 kv. steel tower lines 125 mi. long. A total of 760 mi. of aluminum wire with steel core was used on this line, together with 520 mi. of galvanized plow steel ground wire together with 2254 steel towers, 143,500 insulators and other auxiliary equipment. Construction of this line, the first 220 kv. transmission line to be built in New England, was a tremendous job in itself but the story of this work is outside the scope of this article. A substation for switching and future distribution was built near Franklin, N. H., and called the Central New Hampshire substation. At Tewksbury, Mass., the receiving end of the line, is another substation containing seven 23,000 kv-a., 220/110/13.8 kv. water-cooled, oil insulated outdoor transformers with switchyard and control room, details of which cannot be given here.

Construction of the Fifteen-Mile Falls Development was one of the largest construction jobs ever carried on in New England. The details of the work involved solution of unusual problems, meeting emergencies such as flood conditions and bad weather and the proper coördination of men and materials where needed at the proper time. The working out of these details by the designing and executive forces and the carrying out of the plans by the field forces to complete the plant well in advance of schedule required the utmost coöperation and efficiency on the part of all concerned. The forces of the New England Power Association have successfully carried out a development that promises to be of great value to the whole of New England. We are indebted to the engineering and publicity departments of the company for the heartiest coöperation in supplying data used in this article.

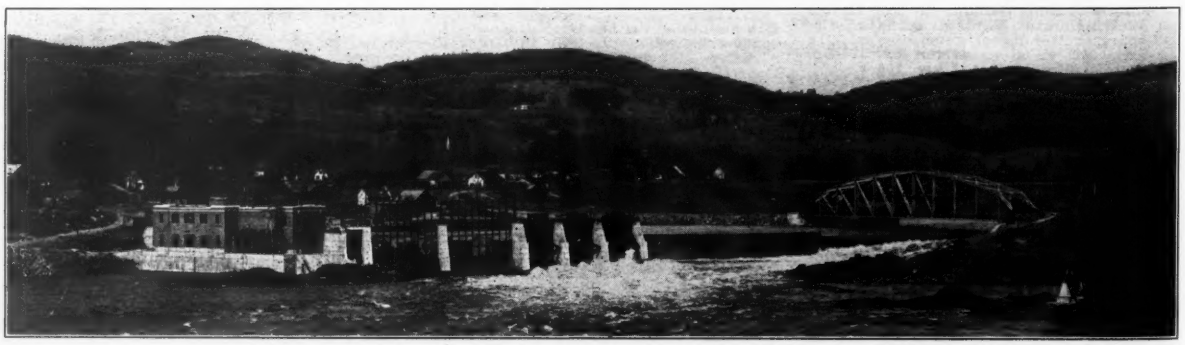


FIG. 6. GENERAL VIEW OF McINDOES FALLS PLANT, SEVEN MILES DOWNSTREAM FROM LOWER DEVELOPMENT

Reheat---Practice, Operation and Control

Methods of Reheating Followed by American Stations Designed for Gas, Steam or Combination Reheat

RESUPERHEATING, or reheating as it is now commonly called, has for the past five years been accorded a definite place in power plant design. Economical turbine operation places a maximum limit of about 10 per cent moisture in the exhaust steam and with present temperature limits of 750—800 deg. F. this moisture content is reached with pressures of about 450—500 lb. In order to take advantage of higher pressures, the high-pressure steam is expanded to or about the saturation point in a high-pressure element of a compound turbine. This lower pressure steam is then resuperheated, usually to approximately the initial temperature, and expanded to condenser pressure in the low-pressure turbine element.

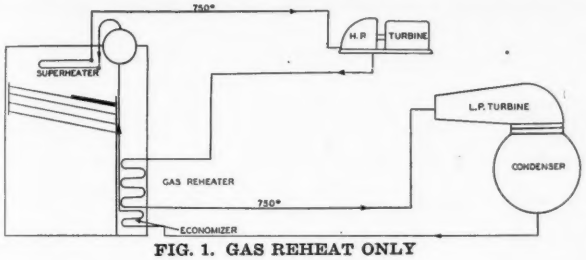


FIG. 1. GAS REHEAT ONLY

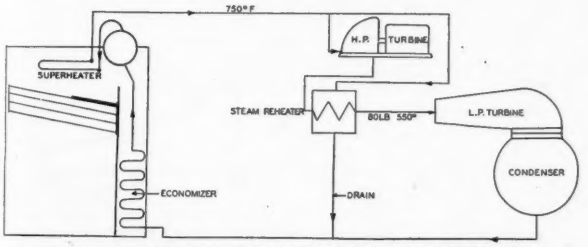


FIG. 2. STEAM REHEAT ONLY WITH ONE HEATER

Reheating may be accomplished in a number of different ways such as a separately fired superheater, a steam superheater, a radiant or convection superheater or any combination of the above. Practically, the radiant, convection and steam heaters have been found most satisfactory.

Flue Gas Reheaters

Diagrammatically a number of reheat schemes are shown in Figs. 1 to 5. Straight gas reheat, which was the first system used, is illustrated by the first sketch. Steam is reheated to 750 deg. F. between the turbine elements. This system necessitates the use of both standard and reheat boilers so that the degree of reheat can be controlled by the rate of firing the reheat unit. Deepwater Station is the most recent installation of this type.

In the early installations, piping was complicated with this system because of the long runs of comparatively low-pressure steam lines. To eliminate these complications, the steam reheater as shown by Fig. 2 was introduced. The heating element is located between the turbine elements and the low-pressure steam is heated by the superheated high-pressure steam. It is obvious that the reheat temperature is limited to the saturation temperature of the high-pressure steam, that is about 550 deg. F. with 1400-lb. boilers. Ford's River Rouge Station is the last to use this method.

Against the simplicity of this system must be balanced the difference of practically 200 deg. of superheat in the steam to the low-pressure element, roughly a kilowatt for every 40 lb. steam flow, and the virtual loss of the heat head of the high pressure superheated steam used in the coils.

Steam Reheaters in Series

Advantage of the superheated high pressure steam temperature heat head can be taken advantage of by using two steam reheaters in series as in Fig. 4. This arrangement is used at Deepwater (Texas). One reheater is of the throughfare type where the high pressure superheat is reduced about 100 deg. F. and the low-pressure steam superheat increased about 150 deg. F. at practically constant pressure.

The other heater is a dead end type which brings the reheat temperature to approximately the high-pressure saturation point. Until recently, superheater, valve and piping manufacturers were not as backward about high temperature equipment as the turbine manufacturers so that by raising the high-pressure superheat to about 800—850 deg. F. the throughfare heater could be used to give practically the allowable maximum temperature to both turbines; that is, its performance was directly comparable with the gas reheater.

Another steam reheater arrangement is shown by the diagram of Fig. 3. Here a single heater mounted

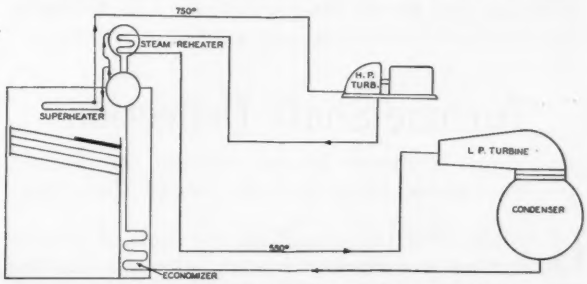


FIG. 3. STEAM REHEAT WITH HEATER DRAINED BY GRAVITY

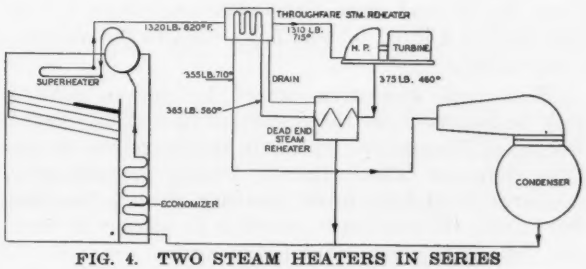


FIG. 4. TWO STEAM HEATERS IN SERIES

directly above the boiler drum is supplied with high pressure saturated steam and drained by gravity directly back to the drum so as to utilize the entire heat head. Although avoiding the use of superheated steam and complications of drainage equipment, this system requires the same piping as a gas reheater. It is used at Concepcion Road, where conditions are unusual inasmuch as the high-pressure plant was superimposed on a low-pressure plant and the allowable reheat temperature is limited to 550 deg. by the old equipment.

Combination Reheaters

Solid lines of Fig. 5 show the combination steam and gas reheater arrangement as used in the three recent stations, South Amboy, Gilbert and Station A.

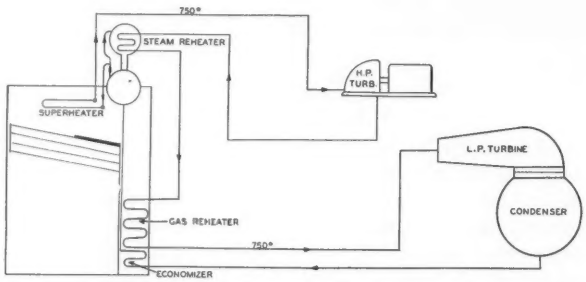


FIG. 5. COMBINATION GAS AND STEAM REHEAT

Saturated steam reheaters are used and so arranged that they drain by gravity to the main boiler drum.

The primary purpose of the combination reheater is to give control of the final temperature. With a gas reheater alone, the temperature of the reheated steam will increase with the boiler rating due to the higher gas temperatures and velocities. By heating in two steps, the first with steam and the second with flue gas, the proportionate work done in each can be varied with the load. At light loads, the steam reheater will do the maximum amount of work. As the load increases, the steam supply to the steam heater is decreased, throwing additional load on the gas reheater, until at maximum load the steam reheater will be practically cut out.

Turbine Shaft Deflection

Distortion of Shafts During Cooling and Warming Up Periods Prevented By Proper Operation

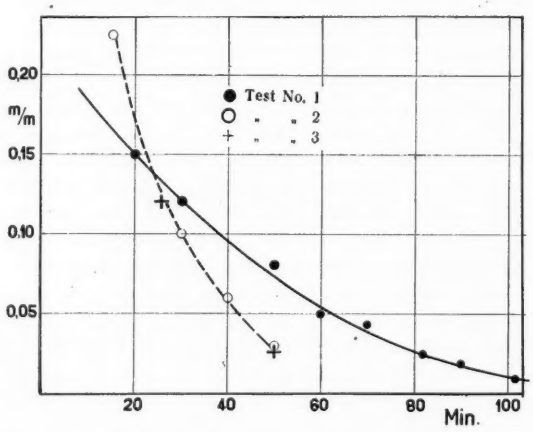
UNDER NORMAL conditions the shaft of a steam turbine is uniformly heated but while shutting down partial cooling occurs faster in some parts than in others and distortion may result. Measurements show that 36 and more hours sometime elapse before the shaft of a large turbine has cooled to the ambient temperature.

This shaft distortion caused by uneven cooling may be as serious as the distortion caused by uneven warming. Experience gained in the operation of turbines, however, shows that if certain precautionary measures are taken, when shutting down a machine and during the stand-still period, it is possible to obviate difficulties when starting up again.

Temporary bending of the shaft has been observed repeatedly in service but experience shows that such a shaft may be straightened by heating it up with steam while running at a low speed of approximately 200 r.p.m.

Data from which the curves were plotted were taken by Escher Wyss & Co. and illustrate the deflections measured on a turbine shaft during the time it was being straightened by heating up at a low rotative speed. Test 1 corresponds to and represents conditions after a standstill of about 48 hours, during which period the shaft was not moved. The decrease in shaft deflection during the heating up period, at a speed of from 80 to 100 r.p.m., is shown by the curve. Test 2 was made after a standstill of 10 hr.; the shaft was not cooled down completely and, of course, warmed up much quicker Test 3 was taken after an approximately 5 hr. standstill and is practically identical to test No. 2.

If a motor driven barring mechanism is supplied, it should be operated during each standstill until the



DEFLECTIONS OF IMPROPERLY COOLED TURBINE SHAFTS UNDER DIFFERENT CONDITIONS

turbine shaft has cooled down completely. If only a lever and rack is provided, the position of the rotor should be altered by about 45 deg. at intervals of 30 min. at first and later on every hour. If it is impossible to do this, it may be taken for granted that the shaft will become deformed while cooling down, and when restarting must be heated at a low speed until it runs true again.

If the turbine has to be restarted before the shaft is entirely cool, increased care must be taken owing to the uncertainty regarding this deflection. Under no conditions should the interior of the turbine be heated while the spindle is standing still, as this will invariably cause deformation of the shaft. For the same reason, sealing steam must never be admitted to the stuffing-box when the shaft is at rest.

Since belts should be impervious to moisture and should stand up under conditions where they are to operate a variety of materials treatment and forms are needed to meet various conditions. But leather belts find the widest use in most plants.

Comparison of Natural Gas Fuels

Part IV

Specific Heat of Waste Gases and Theoretical Flame Temperatures

By Palmer B. Place
Combustion Engineer, New York

SPECIFIC HEAT of a gas varies with the composition of the gas, with the amount of water vapor present and with the temperature. The specific heat value of interest to the combustion engineer and the one referred to in this article is the mean or average specific heat over a given temperature range for gases under constant pressure.

Much research has been done on the determination of the specific heats of gases over the temperature ranges obtaining in combustion practice and accurate values are available in the literature.

For all practical purposes and particularly for comparative purposes, the refinement offered by some of these values is unnecessary. At temperatures ranging from 100 to 800 deg. F., the use of a constant value of

TABLE I. EFFECT OF TEMPERATURE AND WATER-VAPOR ON MEAN SPECIFIC HEATS

Fuel Sample No.	1		8	
Per cent Excess Air	0	80	0	80
Per cent CO_2	11.65	6.17	15.01	8.08
Per cent O_2	0.0	9.86	0.0	9.65
Dry gases lb/lb fuel	15.6	29.0	9.1	16.5
Water Vapor " "	2.2	2.2	1.2	1.2
Wet gases " "	17.8	31.2	10.3	17.7
Per cent water vapor	12.40	7.00	11.30	7.10
Mean specific heat - dry gases at $0^{\circ}F$	.239	.239	.237	.238
1000	.249	.248	.248	.247
2000	.261	.258	.260	.258
3000	.271	.267	.271	.267
4000	.281	.277	.282	.277
Mean specific heat - wet gases at $0^{\circ}F$	.265	.254	.261	.252
1000	.278	.264	.275	.263
2000	.293	.276	.289	.275
3000	.308	.288	.305	.287
4000	.327	.303	.323	.302

0.24 B.t.u. per lb. for air, 0.242 for dry gases, and 0.48 for water vapor is quite satisfactory. This temperature range will cover most boiler exit gas loss calculations.

Determination of Specific Heat of Waste Gases

The mean specific heat of the wet gases may readily be calculated by simple proportion, as shown in the following example,

Dry gases—lb. per lb. fuel	15.0
Water vapor—lb. per lb. fuel	0.6

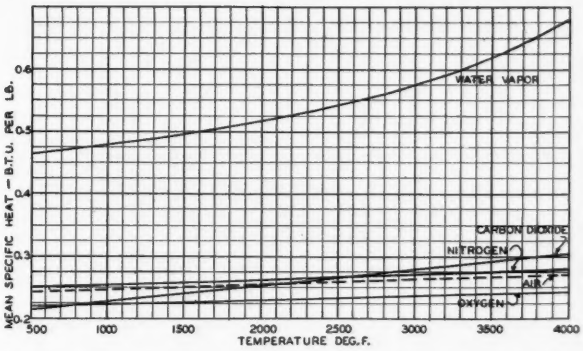


FIG. 1. MEAN SPECIFIC HEAT OF PRODUCTS OF COMBUSTION

Total wet gases—lb. per lb. fuel		15.6
15.0 × .242	= 3.630	
0.6 × .48	= .288	
15.6 lb.	= 3.918	
1 lb.	= .251	B.t.u. per lb. wet gases

For higher temperature ranges and for calculating theoretical flame temperatures, it is desirable to determine the specific heat for each case in question. The specific heats for the usual constituents of furnace gases, namely, water vapor, carbon dioxide, nitrogen and oxygen, have been established and it is only necessary to know the analysis of a waste gas to calculate its mean specific heat at any desired temperature.

Recently determined values of the mean specific heat of air, water vapor, nitrogen, oxygen and carbon dioxide are given for temperatures from 500 to 4000 deg. F. in Fig. 1. The value given at any temperature is the mean or average specific heat from 0 to that temperature. The values, however, may be used without serious error for the specific heat from 100 deg. or room temperature.

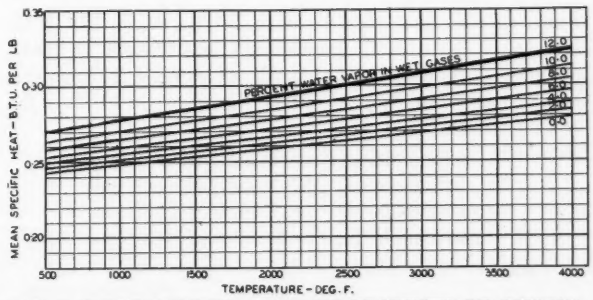


FIG. 2. MEAN SPECIFIC HEAT OF PRODUCTS OF COMBUSTION OF NATURAL GAS FUELS

TABLE II. ANALYSIS AND HEATING VALUE* OF SELECTED NATURAL GASES

Sample No.	CH_4	C_2H_6	C_3H_8	Inerts	Btu/lb High	Water vapor formed	Btu/lb low
1	98.5	-	-	1.5	23466	2.20	21156
2	91.3	4.5	-	4.2	21956	2.04	19814
3	84.7	9.4	4.3	1.6	22793	2.07	20620
4	80.5	18.5	-	1.0	23077	2.08	20893
5	73.2	25.6	-	1.2	22802	2.03	20670
6	77.5	16.0	-	6.5	20057	1.82	18146
7	50.6	10.9	-	38.5	12000	1.09	10855
8	59.1	14.5	-	26.4	12767	1.15	11560
9	32.2	67.0	-	0.8	22053	1.88	20080
10	-	31.8	67.7	0.5	21860	1.67	20106

*See Article II, Table I, April 15, 1931 issue page 447

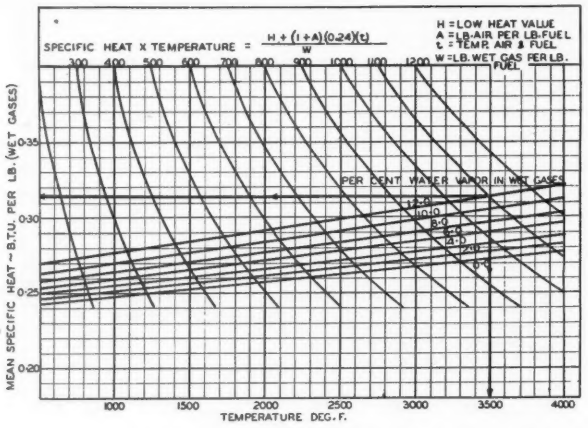

SPECIFIC HEAT X TEMPERATURE = H + (1+A)(0.24)(t) / W
H = LOW HEAT VALUE
A = LB. AIR PER LB. FUEL
t = TEMP. AIR & FUEL
W = LB. WET GAS PER LB. FUEL
300 400 500 600 700 800 900 1000 1100 1200
PER CENT WATER VAPOR IN WET GASES
MEAN SPECIFIC HEAT ~ B.T.U. PER LB. (WET GASES)
0.35
0.30
0.25
0.20
1000 1500 2000 2500 3000 3500 4000
TEMPERATURE DEG. F.

FIG. 3. FLAME TEMPERATURE—SPECIFIC HEAT CHART

TABLE III. THEORETICAL FLAME TEMPERATURES** OF SELECTED NATURAL GASES

Sample No.	Air Lb per	Wet Gases lb fuel	Per cent Water Vapor	Air Temp	T x C_p	C_p	T
1	16.80	17.80	12.40	100	1213	.320	3780
2	15.85	17.35	11.80	"	1165	.318	3720
3	16.50	17.47	11.90	"	1205	.318	3800
4	16.70	17.64	11.80	"	1210	.318	3800
5	16.45	17.50	11.60	"	1202	.316	3800
6	14.55	15.48	11.80	"	1195	.317	3770
7	8.67	9.69	11.20	"	1145	.314	3650
8	9.25	10.25	11.30	"	1151	.313	3670
9	16.20	17.22	10.90	"	1190	.314	3780
10	15.62	16.59	9.90	"	1235	.312	3940

** All temperatures in degrees Fahrenheit. Air and fuel temperature assumed at 100°F. 0% excess air assumed.

Calculation of the specific heat for any waste gas mixture is best shown by example:

To find the mean specific heat from 100 to 2000 deg. F. of the waste gases formed when natural gas sample No. 1 is burned with 40 per cent excess air.

The waste gases contain 8.05% CO_2, 6.44% O_2, 85.51% N_2 by vol. and 2.2 lb. of water vapor per lb. of fuel burned.

Since specific heats are given in B.t.u. per lb., the volumetric analysis of the gases must be changed to gravimetric. Referring to Table IV of Article III of this series, page 546 May 15, 1931, issue, we find that the gases contain

.985 mols CO_2 per mol of fuel gas
.788 mols O_2 per mol of fuel gas
10.438 mols N_2 per mol of fuel gas
1.970 mols H_2O per mol of fuel gas

then

		Percent by weight dry gases	wet gases
.985 × 44	43.34	12.02	10.94
.788 × 32	25.22	6.99	6.36
10.438 × 28	292.26	80.99	73.75
	360.82	100.00	
1.970 × 18	35.46		8.95
	396.28		100.00

From Fig. 1, the mean specific heats for CO_2, O_2, N_2, and H_2O are found for T = 2000 deg. F. and the mean specific heat of the dry and wet gases is calculated by proportion as follows:

TABLE IV. EFFECT OF EXCESS AIR ON FLAME TEMPERATURE

Natural Gas Sample No. 1

Per cent Excess Air	0	20	40	60	80	100
Air-lb/lb fuel	16.8	20.2	23.5	26.9	30.2	33.6
Wet gases "	17.8	21.2	24.5	27.9	31.2	34.6
% water vapor	12.30	10.40	9.00	7.90	7.00	6.40
Air & fuel temp	100	100	100	100	100	100
Temp x Sp. ht	1213	1022	887	782	702	635
Flame temp	3780	3360	3000	2710	2500	2280
Sp. ht.	.320	.306	.295	.288	.280	.275

Natural Gas Sample No. 8

Air-lb/lb fuel	9.3	11.1	12.9	14.8	16.7	18.5
Wet gases "	10.3	12.1	13.9	15.8	17.6	19.5
% water vapor	11.30	9.60	8.30	7.30	6.60	6.00
Air & fuel temp	100	100	100	100	100	100
Temp x Sp. ht.	1146	979	853	755	681	617
Flame temp	3670	3260	2900	2640	2420	2260
Sp. ht.	.313	.300	.294	.285	.280	.274

		Dry Gases	Wet Gases
CO_2	.255 × .1202 =	.0307	
	.255 × .1094 =		.0279
O_2	.229 × .0699 =	.0160	
	.229 × .0636 =		.0146
N_2	.262 × .8099 =	.2122	
	.262 × .7375 =		.1932
H_2O	.517 × .0895 =		.0460
Mean specific heat =		.259	.282

In Table I the mean specific heats at 0, 1000, 2000, 3000, and 4000 deg. F. are given for the dry and wet gases formed when Samples No. 1 and 8 are burned with no excess air and with 80 per cent excess air. Inspection shows that the specific heat of the dry gases does not vary appreciably with changes in the composition of the dry gases but does change with variations in temperature. In other words the mean specific heat of the dry gases formed by the combustion of natural gas fuels may safely be taken as follows:

Temperature deg. F.	Mean specific heat
0	.238
1000	.248
2000	.259
3000	.269
4000	.279

In the case of the wet gases, the specific heat increases both with temperature and with the amount of water vapor present. For usual calculations, the mean specific heat for wet gases may be taken as follows:

Temp. deg F.	Percent by weight of water vapor present 12.00	10.0	8.00	6.00	4.00	2.00	0
0	.265	.260	.255	.250	.246	.242	.238
1000	.278	.273	.266	.261	.256	.252	.248
2000	.293	.286	.278	.266	2.62	.269	2.59
3000	.308	.301	.290	.284	.278	.273	.269
4000	.327	.318	.307	.298	.290	.284	.279

These values are plotted in Fig. 2.

Flame Temperature Calculations

The theoretical flame temperature is the temperature that would result if all of the available heat is used to increase the sensible heat of the wet products of combustion. The available heat is the sum of the net or available heat of combustion of the fuel and the sensible heat in the fuel and in the air used for its combustion. The available or net heat of combustion of fuels has

been explained in a previous article of this series. The heat values and analyses of ten selected natural gases are given in Table II.

Mathematically the theoretical flame temperature is expressed as follows:

$$T = \frac{H + (1 + A)\ (0.24)\ (t)}{(C_p)\ (W)}$$

where

T is the theoretical flame temperature in deg. F.
H is the low or net heat value of the fuel.
A is the lb. of air per lb. of fuel used for combustion.
t is the temperature of the fuel and air in deg. F.*
C_p is the mean specific heat of the wet products of combustion from O to T deg. F. (See Fig. 2).
W is the lb. of wet products of combustion per lb. of fuel.

It is evident that there will be difficulty in using this equation when it is remembered that the specific heat depends on the temperature which in this case is an unknown quantity. In other words, we cannot solve for T until we know C_p and we do not know what

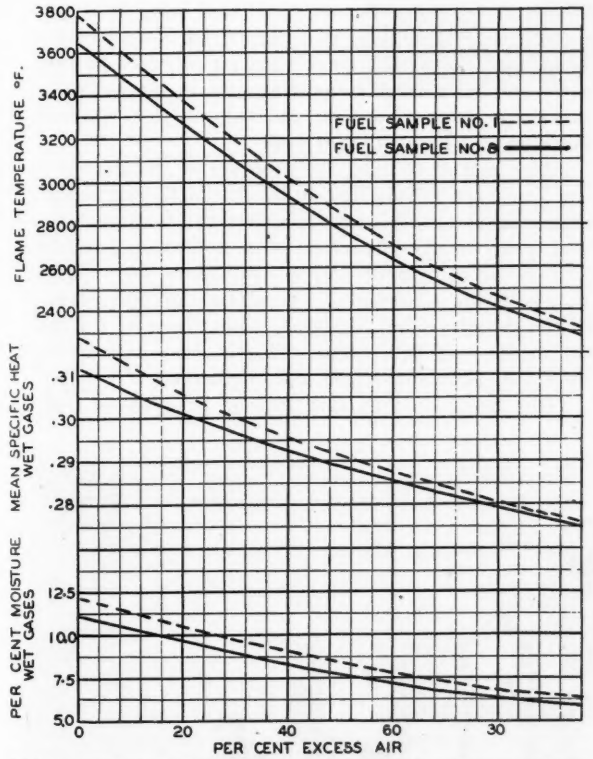


FIG. 4. EFFECT OF EXCESS AIR ON FLAME TEMPERATURE AND SPECIFIC HEAT

C_p is until we know what T is. There are two ways out of this difficulty. The usual method is the trial method. A specific heat is assumed and T determined. If the calculated temperature is the correct one for the specific heat assumed, then the conditions of the equation are fulfilled. If it is not the correct temperature, then other values of C_p are chosen and tried until the right one is found. This is tedious and may be eliminated by the following method. Resolve the equation to

$$T \times C_p = \frac{H + (1 + A)\ (0.24)\ (t)}{W}$$

and solve for $T \times C_p$. In Fig. 3, the specific heat values of Fig. 2 are superimposed with lines of constant $T \times C_p$ products. For any given product it is only necessary to follow along the line of constant product to the specific heat line for the fuel in question. The intersection of these two lines gives simultaneously, the theoretical flame temperature and the mean specific heat of the products of combustion for this temperature.

In Table III, the theoretical flame temperatures are developed for the ten selected natural gases given in Table II. For these calculations the temperature of the fuel and air has been assumed at 100 deg. F. so that

$$T \times C_p = \frac{H + 24(1 + A)}{W}$$

Although the selected samples represent a wide range in composition and heating value, it will be noted that the variation in flame temperature is comparatively small. For practical purposes, the theoretical flame

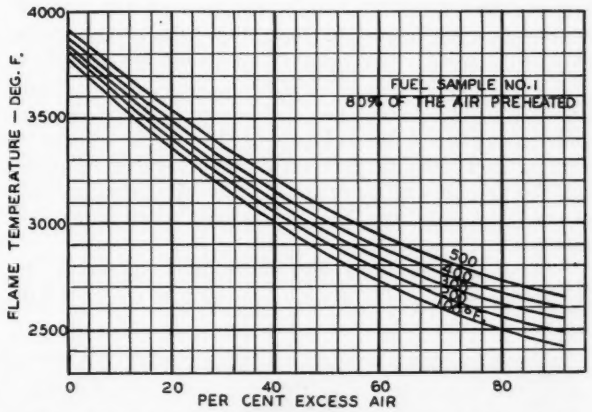


FIG. 5. EFFECT OF PREHEATED AIR ON FLAME TEMPERATURE

temperature and mean specific heat of the wet products of combustion may be taken as 3770 deg. F. and 0.316 B.t.u. per pound respectively, for all natural gas fuels when the temperature of the fuel and air is 100 deg. F. and the fuel is burned with the theoretical amount of air.

In Table IV, the flame temperatures from the combustion of Samples No. 1 and No. 8 with various amounts of excess air, are developed and the results are plotted in Fig. 4. The cooling is considerable, ranging from 100 to 250 deg. F. per 10 per cent excess air. Note that the effects of both samples No. 1 and No. 8 are similar and may be taken as characteristic of the effect of excess air on the flame temperature for all natural gas fuels.

Preheating the air used for combustion raises the flame temperature somewhat. The effect of preheating 80 per cent of the air used for combustion is shown in Fig. 5.

*Usually t is room temperature. If part of the air used for combustion is preheated, the heat content of this air should be calculated separately. Thus in case 80 per cent of the air is preheated to t_2 deg. F. the equation becomes:

$$T = \frac{H + (1 + 0.2A)\ (0.24)\ (t) + (0.8A)\ (0.24)\ (t_2)}{(C_p)\ (W)}$$

The Power Behind New York

Part II. Features of System Operation. Analysis and application of load curves. Factors affecting system operation. Determination of incremental rates. Frequency and voltage regulation

THUS FAR WE have described somewhat briefly the physical aspects and the general plan of operation of the New York Edison System. We shall now proceed with a consideration of certain factors which have to do with the nature of the load and the manner in which these factors affect design and operating conditions.

In the operation of any public utility it is essential that the characteristics of the load be known, for it is the nature and character of the load that determines the amount of installed generating capacity and to a large extent the procedure involved in operating the system. The number of units required on the bus, of course, depends upon the load, but before such units can be connected they must be prepared for operation and this, under normal conditions, may require from one-half to two hours. For this reason, it must be possible to anticipate the demands of the system both as to amount and time so that a sufficient number of units may be prepared to carry this load when it occurs. The characteristics of the load, therefore, must be known and studied constantly.

These considerations only affect daily operation. It is also necessary to know what the value of the load will be a long time ahead so that generating equipment may be provided to handle it. The load on the New York Edison system has grown steadily during the past 30 yr. as may be noted from Fig. 2. This curve is not one of the combined systems but of the New York Edison Co. As a consequence, new equipment must be provided constantly to meet the requirements of the growing system. It is not sufficient to know the load today or tomorrow but it is necessary to know what it is going to be a year from now, two years from now, five years from now. It takes approximately two years to decide upon and get a large generating unit in service, so it is necessary to know a long time ahead just when this machine will have to carry load.

As a matter of fact, the program of installation for the New York Edison System involves a 10-year schedule of new machines, this schedule, however, being corrected each year to take advantage of new developments both as regards equipment and system operation. This 10-year schedule is presented for information and guidance of the executives but of course cannot be used for order or purchase of equipment. This is done only as each development is authorized and engineered.

One by-product of this 10-year program is that it

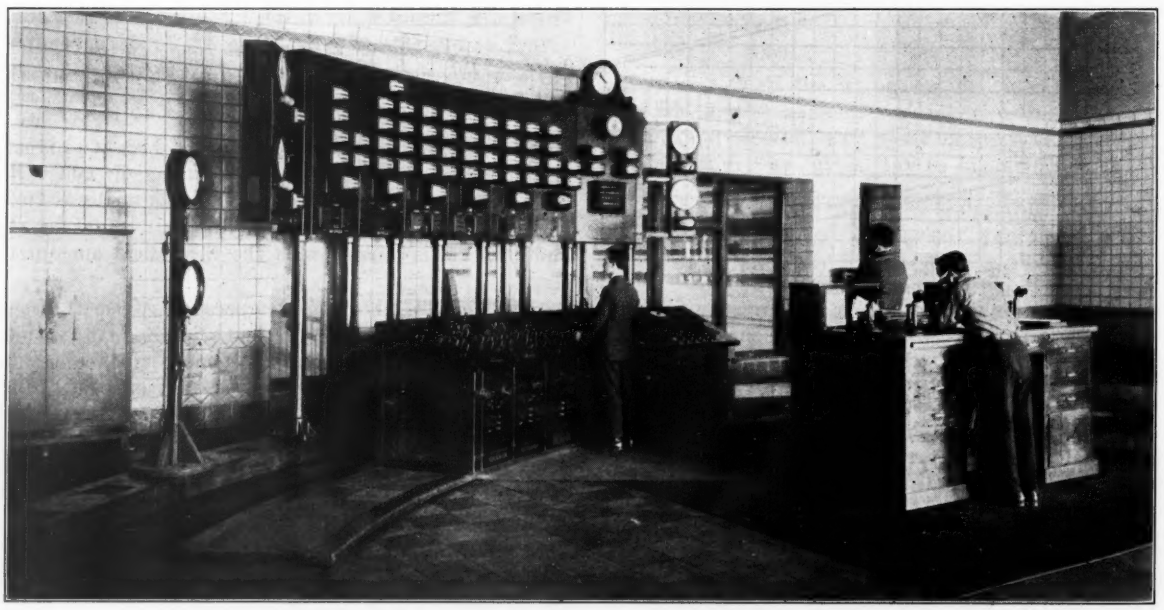


FIG. 1. IN THE MAIN CONTROL ROOM AT EAST RIVER STATION

East River Station

provides knowledge in advance and permits planning of projects in an orderly manner. Under such a plan there can be no hurried or "half-baked" designs and no great amount of overtime is necessary to rush projects to completion.

With regard to the program for the installation of equipment for reserve capacity, there is a general rule in effect which requires that any machine intended to carry the peak load in the fall of the year, shall be ready for operation in the spring of that year. A large generating unit is a complex affair and it requires several months as a rule to adjust it properly and to put it in condition for continuous operation. By having such units ready for operation in the spring, the entire summer season (when the load is light) is available for testing and adjustment. The peak of the year usually commences to build up with the termination of daylight saving time and since this occurs about the end of September, the load begins to build up around the first of October. Thus any new machine which may be required to take over a portion of this peak must be ready to operate in the spring of that year so that all spring and summer months may be available to correct any difficulties which may arise with any new machine. This also removes the necessity of rush work with its attendant danger of poor workmanship and construction.

A further point of interest regarding the program for expansion and development is the rule that sufficient generating capacity be provided so that the system can lose its three largest units, two of these being in one station, without in any way curtailing or interrupting service in any district. This, of course, involves adequate tie capacity between the generating stations and this stipulation is made without reference to frequency. The largest 25-cycle unit at East River Station, for instance, has a rating of 160,000 kw. Since the total capacity in frequency changers on the system is 190,000 kw., it is evident that the loss of the 160,000 kw. 25 cycle machine at East River could be compensated for by supplying the equivalent amount of power from the other stations through the frequency changers.

A further advantage of the use of frequency changers is that they enable one system to take advantage of another system having a more economical operation. It is also stipulated that the total installed capacity should be 20 per cent greater than the maximum instantaneous peak as soon as 20 per cent becomes more than the aggregate of the three largest units.

All of these aspects of system operation, it will be evident, are in some way related to the load so it will be of interest to consider some of the load characteristics.

A study of the load characteristics of the New York Edison Co. is complicated by the fact that energy is supplied at two different frequencies. Because of the differences in the character of the 25 and 60-cycle loads, their respective load curves are not cöincident. In Fig. 3 is shown the 24-hr. demand on the system on the day of the yearly system peak for 1929. This peak usually occurs on about the same day each year. The 25-cycle peak, it will be noted, occurs at 4:30 p.m. while the 60-cycle peak occurs at 5:30 p.m. The system peak occurs at 5:00 p.m. with a total of 1,225,000 kw. The fact that the 25 and 60-cycle peaks do not occur at the same time reduces the total amount of generating capacity required for if the two peaks occurred at the same time, the system peak would have been 1,240,000 kw.

The two predominating types of load which influence the shape of the load curves are the lighting and the industrial loads. The influence of these loads is shown in Fig. 3. After 4:30, the 25-cycle load drops rapidly due principally to the shutting down of manufacturing plants throughout the metropolitan area and the closing

of offices in the lower Manhattan region. The 60-cycle load on the other hand increases to a peak value at 5:30 p.m., dropping but slightly during the subsequent three hours. This load is principally a lighting load. It should be noted that the 25 and 60 cycle loads are approximately equal in value.

In Fig. 5 is shown a typical winter Saturday load curve. The influence of the industrial load is shown by the "valley" created between noon and 4:00 p.m., caused principally by the fact that most industries are shut down at noon on Saturday. The 60-cycle peak is considerably greater than the 25-cycle peak, indicating a greater 60-cycle load than a 25-cycle load.

Such curves as these are used in a variety of ways. They are added together and rearranged and analyzed piece by piece, element by element. They are classified and filed and watched from day to day and year to year so that conditions may always be anticipated. The few examples of the load curves shown here will suffice to indicate the more general characteristics but there are many conditions which may cause sudden variations in the load curves. Consider, for example, the effect of the existence in the community of a certain group or race of people. In Fig. 6 is shown the effect on the system load due to the Jewish holiday Rosh Hashana. In any community other than New York such an occasion would have a negligible effect but here it results in a decrease of some 100,000 kw. of load which is appreciable even on this great system.

In a similar way important events, such as a nationally important prize fight or an election, may cause wide fluctuation from the normal average load. It is important, therefore, to know something as to the effects of such events upon the load in advance, and this information is derived from previous load curves.

From the load curves, various "factors" are determined which are used in the operation and future planning of the system. The question of load factor for

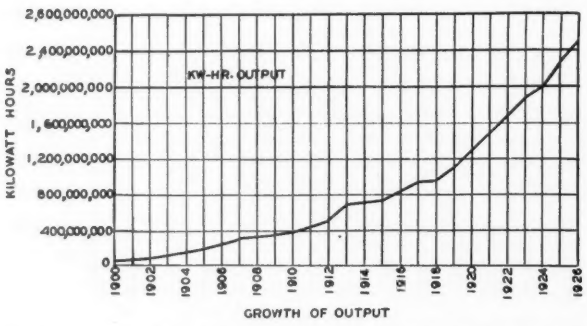


FIG. 2. CURVE SHOWING GROWTH OF OUTPUT OF THE NEW YORK EDISON COMPANY FOR PERIOD BETWEEN 1900 AND 1926

instance is important in determining generating costs. Plant factor which is defined as the ratio of the average net load for a prescribed period to the installed main generator capacity, provides the relation between output and installed generating capacity. Station capacity factor, which is defined as the ratio of the average net load for a prescribed period to the station capacity is important for comparing generating station performance where one or more stations have boiler capacity less than turbine capacity. Consider, for instance, the following data in regard to plant and station capacity factors for the three major stations on the system, during the month of June, 1929:

	Plant Factor	Station Capacity Factor
East River	46.6 per cent	46.6 per cent
Hell Gate	26.4 per cent	66.5 per cent
Hudson Avenue	32.4 per cent	37.9 per cent

On a plant factor basis, it would seem from this that Hell Gate Station was underloaded; but on a station capacity factor basis, it is evident that in proportion to the maximum output of the station, the load was considerably greater.

From these few examples, it is evident that studies of the load curves and the determination of factors such as these constitutes an essential part of the normal operating procedure.

One of the functions of the system operator is the scheduling of units on and off the bus in accordance with the system load. It is, of course, impossible for any man or any group of men to keep in touch with load conditions from minute to minute and regulate the load which a particular station should carry and as it would be equally impossible for any operating organization to operate economically under such haphazard loading, the loading schedule is made out in advance

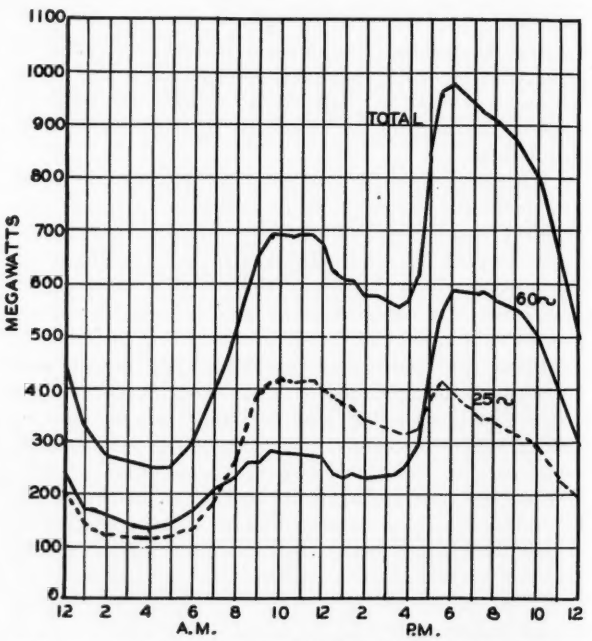


FIG. 3. DAILY LOAD CURVE OF THE NEW YORK EDISON SYSTEM ON THE DAY OF THE YEARLY PEAK, TUESDAY, DEC. 17, 1926

so that the operators in each station will know how much load it should carry under given conditions. This loading schedule is the foundation of both reliable service and economical performance as the correct division of the systems load is based on the knowledge of each individual unit's performance over its entire capacity range and the relation of each unit's performance to the system as a whole with due regard to reserve capacity in generating units and tie lines.

The loading schedule is made up in accordance with

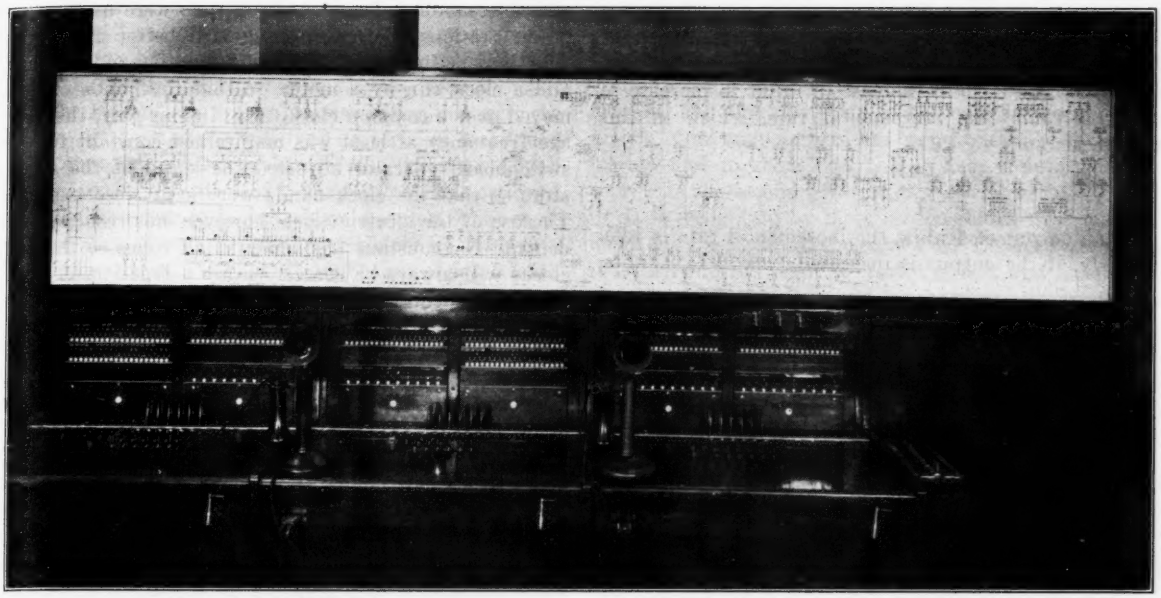


FIG. 4. TELEPHONE BOARD, SYSTEM OPERATOR'S ROOM FOR THE BROOKLYN EDISON CO.

the data developed by the Economy Committee, whose function it is to determine the most economical loading for a given condition. It is, of course, impossible to describe the entire procedure by which the economy committee arrives at its conclusions regarding the most economical use of equipment but a brief consideration of some of the fundamental principles involved may be of interest. The object, in the economical operation of the system is to secure the greatest electrical output for the lowest cost of coal burned. All considerations, therefore, ultimately revert to the boiler room.

Each generating station has different characteristics so each station is considered separately and in order to simplify the problem of determining the performance of each station, the computations for the boiler and turbine room are made separately.

In the case of the boiler room, the general aim is to obtain any given boiler output at the lowest cost. In a station comprised of different types of boilers, this is obtained when the distribution of the load between boilers is made so as to obtain a minimum coal consumption. The effect of superheat on the steam consumption of the turbine, the amount of power consumed by the boiler auxiliaries and the coal cost are some of the factors which must be included in the computation in order to make a true comparison for the distribution of load among boilers.

In the turbine room also, it is the aim to obtain the smallest heat consumption of the turbine for any given output. The number of units to be on the line and the amount of load to be allotted to each unit must be deterffmined. For the purpose of calculation, it is always assumed that the output is fixed and beyond control.

Finally the boiler room performance computations are combined with the turbine performances computations in order to determine the best operating arrangement for a given load.

This whole question of proper load division is based largely upon the determination of what are known as incremental rates. The relation between the output and input of any machine, irrespective of its size, type or operating characteristics, can be expressed in the form of a curve known as an input-output curve. The ordinates of this curve will express the input, the abcissa, the output. Such a curve is shown in Fig. 5. In this example, to simplify the dicussion the output and input are expressed in "units." Suppose the machine to be operating at an output of 4 units. The input corresponding to this unit is 4.4 units. Suppose further that

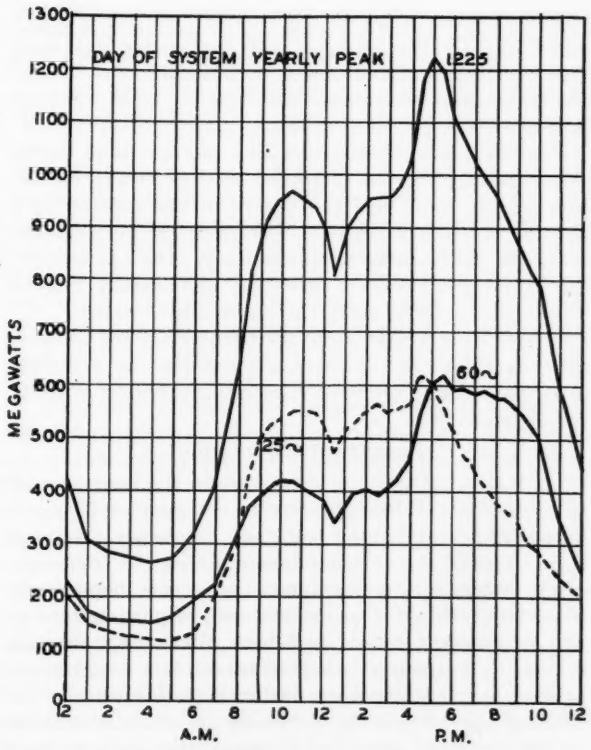


FIG. 5. TYPICAL WINTER SATURDAY LOAD CURVE OF THE NEW YORK EDISON SYSTEM. JANUARY 4, 1930

it is desired to increase the output to 5 units. The input will then be increased to 5.45 units. Then for an increase of 1 unit in output, the input will have to be increased 1.05 units. The ratio of increase in input to increase in output is called the incremental rate, which in this instance amounts to

$$\frac{1.05}{1} = 1.05$$

At an output of 4 units the incremental rate is 1.05. Similarly, if the output is increased from 8 to 9 units,

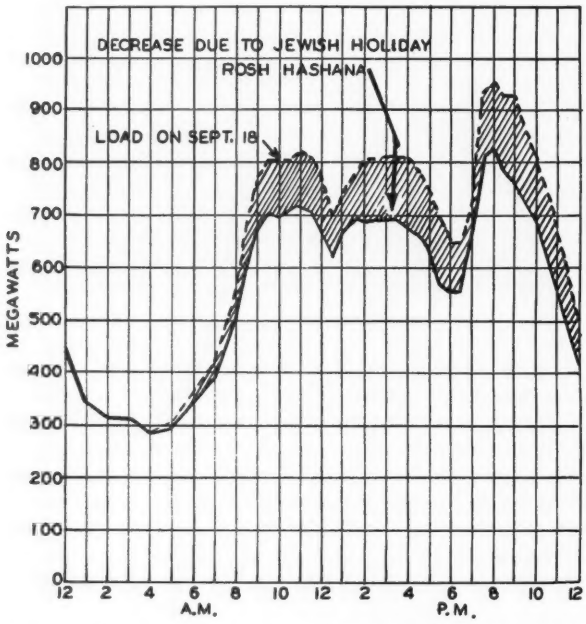


FIG. 6. LOAD CURVE OF THE SYSTEM FOR TUESDAY, SEPT. 23, 1930, SHOWING THE DECREASE IN CONSUMPTION DUE TO THE JEWISH HOLIDAY ROSH HASHANA

the increase in output is from 9.55 to 11.65 units or 2.10 units.

The incremental rate for the input-output curve shown in Fig. 7 can be computed mathematically by setting up an equal equation curve, differentiating and plotting the first derivative. For practical purposes recourse to mathematics is unnecessary. The accompanying table shows clearly how the incremental rate is derived and plotted using the input-output curve.

These incremental rates are worked out for all possible conditions so that with a given load on a station or on the system, the most economical selection of units can be made.

Frequency Regulation

A feature of particular interest in the operation of the New York Edison System is the manner of regulating and maintaining constant frequency. During recent years, the problem of maintaining the frequency of the system within close limits has become increasingly important. Manufacturing processes require motors to run at constant speeds and with alternating current, unless the frequency is kept constant this requirement cannot be met. Another factor contributing to this phase of operation is the increasing use of electric clocks. As the control of frequency became better, more reliance was placed on it for operating clocks driven by synchronous motors. These clocks in turn were used by the power stations for maintaining still better frequency. This was accomplished by combining a standard clock and a clock run by a motor, so that the hands of both moved over a common clock face. In this way, the average frequency at least was maintained constant for the switchboard operator adjusted the speed of the generators so that the clock hands were kept close together. The use of the electric clock, however, has resulted in a demand for constant frequency at all times so that the clocks will always be correct within a fraction of a second. This demand is being met by extremely sensitive frequency meters which are capable of indicating variation of from 1/20 to 1/100 of a cycle. By means of these the operators are enabled to maintain the required accuracy. At times of changing load, this means frequent adjustment of the governors, and this is done by means of a switch on the main control board which operates a small motor geared to a spring on the turbine governor. The effect of using the switch is to tighten or reduce the tension of the spring and this in turn causes the governor to open or close the throttle valve, increasing or decreasing its speed.

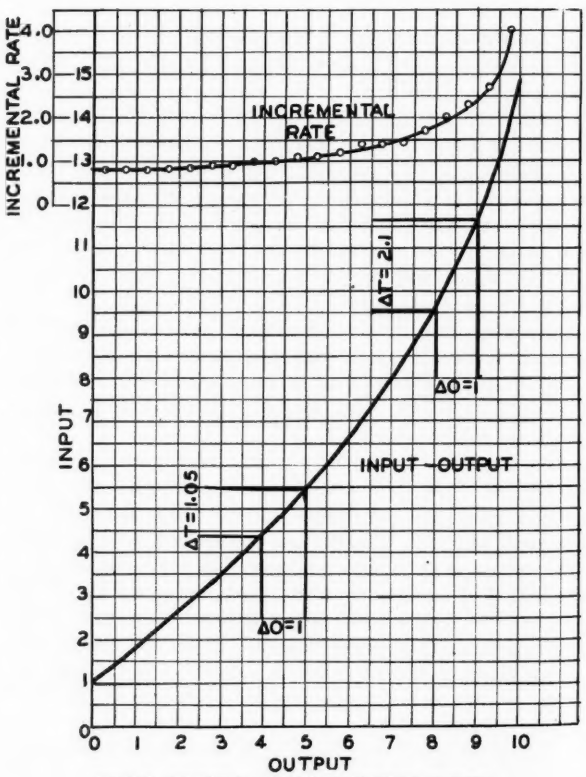


FIG. 7. TYPICAL INPUT-OUTPUT CURVE

On a large system such as the New York Edison, frequency control is not sufficient to divide the load properly and in the proportions desired between the various stations. It is the practice, therefore, to carry what is known as "block load" at all stations but one, and that station maintains the frequency and by so doing picks up the remaining load. The station which does this is Hell Gate.

In practice, the System Operator assigns a definite block load to six of the generating stations while Hell

Gate thus takes the variations In a station carrying "block load" the operator maintains the assigned load on the station by manipulation of the turbine governors without considering frequency.

If the load of the system increases, for instance, the turbines of the stations will tend to pick up more load and in that case it is the duty of the operators in all stations to adjust the load carried to the assigned amount. The result is a slight drop in system frequency. This, however, is counteracted immediately by the action of the operator at Hell Gate. He, being charged with maintaining the frequency, immediately adjusts his governors to increase the speed and pick up load until the frequency is restored to normal. Thus all the increase in load is picked up by one station. The system operator, however, receives frequent reports of loads carried from all the stations and if the load carried by Hell Gate increases or decreases beyond certain standard loads for that time of the day, he corrects conditions by changing the "block loads" of the other stations.

Voltage Regulation

Quite as important as the matter of frequency is that of proper voltage regulation. On the New York Edison system this is accomplished, manually, through remote control, by varying the excitation of the generator fields. When several alternators are operating in parallel on a common bus it is usually necessary to adjust the fields of all the generators to change the bus voltage. If the field of only one generator is adjusted, the effect is a redistribution of the reactive power supplied by the generators to the bus without materially affecting the loads supplied.

CALCULATION OF INCREMENTAL RATE CURVE FROM INPUT-OUTPUT CURVE

Output	Incremental Output	Input	Incremental Input	Incremental Rate	Output against which Incremental Rate is Plotted
0		1.0			
	0.5		0.4	0.8	0.25
0.5		1.4			
	0.5		0.4	0.8	0.75
1.0		1.8			
	0.5		0.4	0.8	1.25
1.5		2.2			
	0.5		0.4	0.8	1.75
2.0		2.6			
	0.5		0.4	0.8	2.25
2.5		3.0			
	0.5		0.45	0.9	2.75
3.0		3.45			
	0.5		0.45	0.9	3.25
3.5		3.9			
	0.5		0.5	1.0	3.75
4.0		4.4			
	0.5		0.5	1.0	4.25
4.5		4.9			
	0.5		0.55	1.1	4.75
5.0		5.45			
	0.5		0.55	1.1	5.25
5.5		6.0			
	0.5		0.6	1.2	5.75
6.0		6.6			
	0.5		0.7	1.4	6.25
6.5		7.3			
	0.5		0.7	1.4	6.75
7.0		8.0			
	0.5		0.7	1.4	7.25
7.5		8.7			
	0.5		0.85	1.7	7.75
8.0		9.55			
	0.5		1.0	2.0	8.25
8.5		10.5			
	0.5		1.15	2.3	8.75
9.0		11.65			
	0.5		1.35	2.7	9.25
9.5		13.0			
	0.5		2.0	4.0	9.75
10.0		15.0			

In the foregoing discussion we have considered briefly the principal factors which affect reliable and economical operation of the system. In an article of this type, it is impossible, of course, to discuss all of these factors in great detail, for many of them are complex engineering problems in themselves. The study of incremental rates, for instance, involves details, knowledge and analysis of nearly all aspects of electric power generation, and this obviously is beyond the scope of this article. Our purpose here has been to describe the organization and to show how this system supplies electric service to the second greatest city in the world.

It is recognized by those responsible for the management and operation of the New York Edison system that it is the public's right to have the best and most economical service possible under any given circumstances, furnished with all possible courtesy and attention

The purpose of a system of this kind is two-fold: 1. To make money, that is to provide a fair return to those who invest their capital in it, and 2. To insure service of the highest quality to the consumer, continuously and at the cheapest rate possible. The fact that these requirements are listed in this order does not imply that this is the order of their relative importance for it must be obvious that they are interdependent. And these requirements hold, regardless of whether such a system is privately owned or owned by the municipality or other governmental agency. The only difference is that if it is the latter, the connection between serving the public and the earning of money is less direct, less evident and for this reason liable to be less efficient.

Having thus described the organization, the system and some aspects of its operation, we are now in a position to consider some of the more recent technical and engineering developments which have been made in the generating stations during recent years. This we shall do in a subsequent article.

In an effort to establish a series of standards for machine driving the American Standards Association is sending out a questionnaire on present practice. It covers speeds of shafting and driven machines, diameters of pulleys and of pitch circles of gears and sprockets, widths of pulley faces and belts with pull used per inch of belt width, belt speeds, power transmitted by shafts, by belts and by ropes. It is hoped that a series of standard speeds, diameters and powers can be formulated which will simplify the design and installation of shafting and machine drives. To secure uniformity in data, machine speeds in r.p.m. are defined as follows: For built in and coupled, the driving unit shaft; for geared, the driving pinion; for single pulley, the driven pulley; for cone pulley, the countershaft; for V-belt rope or chain, the driven sheave or sprocket; for friction, the driven shaft.

Questions are sent out to users of machines and to manufacturers with the query whether the following speed series will serve satisfactorily as a basis for future practice:

36	600	7200
56	720	10,620
90	900	15,720
133	1200	23,400
200	1800	34,500
300	2400	51,000
400	3600	

Reply to the questions from any user or manufacturer will be welcomed, the information to be sent to F. S. English, chairman, A. S. M. E., 29 W. 39th St., New York, N. Y.

Oil and Gas Power Engineers Meet at Madison, Wis.

[Selection of Diesel Engines, Operating Data, Flow of Air, Oil Sprays, High-Speed Engines, European Developments, Automatic Diesel-Electric Plants and Waste Heat Recovery Were Discussed]

ANNUAL MEETING of the Oil and Gas Power Division of the American Society of Mechanical Engineers was held June 23 to 26 at the University of Wisconsin, Madison, Wis., with a large attendance of engineers from all parts of the country. The technical sessions were interspersed with entertainment features, trips, banquets and the like. Many of the engineers attended on June 22 the various events connected with the dedication of the new Mechanical Engineering Building at the University.

Concurrently with the Oil and Gas Power meeting, an exhibition of Diesel engines, engine parts and accessories was held. Pistons, piston rings, valves, chains, centrifuges, instruments, lubricators, pumps, pipe, alloys for various Diesel engine parts and other equipment were displayed by twenty-four manufacturers.

On Tuesday, June 23, the first day of the Oil and Gas Power meeting, the opening session was held at 2:00 p. m. presided over by Ben G. Elliott, professor of mechanical engineering at the University of Wisconsin.

Dispersion of Sprays

In the first paper, entitled Dispersion of Sprays in Solid-Injection Oil Engines, Kalman J. De Juhasz, assistant professor of engineering research, Pennsylvania State College, treated first the general principles of atomization of fuel oil. He then discussed experiments relating to spray dispersion carried out by the Engineering Experiment Station of his institution. Two injection systems were investigated: 1, constant pressure injection with mechanically-operated valve; 2, pump injection with hydraulically operated valve. After describing the experimental apparatus and its operation, the author stated some general conclusions arrived at from a large number of charts representing sprays under various conditions.

These conclusions are: 1, the dispersion becomes more even when the injection pressure is increased; 2, the dispersion becomes more even when the oil viscosity is decreased; 3, the dispersion becomes more even when the air density is increased; 4, the cone angle increases with increasing oil pressure, increasing air density and decreasing viscosity of oil; 5, a larger percentage of oil reaches a given distance in a spray having a slender spray cone; 6, no definite trend was noticeable in using cylindrical orifices of the dimensions employed in the tests discussed. Finally, the author emphasized the conclusion that the experimental method described and the procedure of evaluation developed are easy to apply and the results give a means for judging the spray from the point of view of applicability in an engine.

A Quiescent Combustion Chamber was next treated in a paper by John A. Spanogle, N. A. C. A. Langley Field. This was followed by a paper on Experiments on Flow of Air through Engine Valves by E. S. Dennison and T. C. Kerchlee of Westinghouse Electric & Mfg. Co., with discussion opened by W. F. Joachim of the same organization. The formal opening and inspection of exhibits then took place. In the evening a general mixer and entertainment were held.

The second day of the meeting began with a session at 9:00 a. m. at which L. H. Morrison presided. After the report of the Diesel Fuel Research Committee, Wiley Butler, secretary, a paper on the Development of a High Speed L-head Diesel was read by Max Hoffman, Chief Diesel Engineer, Waukesha Motor Co.

Factors in Selecting a Diesel Engine

Selecting a Diesel engine is not easy for many reasons, said Otto Nonnenbruch, Chief Engineer J. P. Morris and De La Vergne, Inc., in beginning his paper on that subject. He reviewed the factors in selecting a manufacturer, emphasizing the need for the highest ethics on the part of manufacturers to maintain good relations between buyers and sellers, good service for the former and a fair profit for the latter. Consulting engineers, he said, can greatly benefit the Diesel engine purchasers and manufacturers by paying careful attention to the Diesel engine, its advancement, design, limitations, applications, accessories, installation and operating troubles.

Selection of a type of engine is made easier by remembering that the greatest assurance of success is not in the type but in the details of design, workmanship and materials proved by the engine's record and the manufacturer's reputation. Conservative ratings, simplicity, proper specifications are important in getting the proper type of engine for the service. Details of bearings, cylinder liners, pistons, governors, lubrication systems and other parts were then treated in detail.

Double Acting Diesel Engines

In less than a decade there has been development of the double-acting Diesel engine into a reliable prime mover, said Louis R. Ford, Consulting Engineer, in his paper on Development of the Double-Acting Engine. Double-acting engines for large power plant work are attracting attention. A committee studying types of equipment for the extension of the Copenhagen electric power station has recommended acceptance of a Burmeister & Wain double-acting, two-cycle engine of 18,500 b. hp. with continuous overload capacity of 22,500 b. hp. At present, says the author, the two-cycle type has forged ahead of the four-cycle design.

In reviewing the steps in the development, the author gave details of packing the piston rods and obtaining good combustion in the lower end of the cylinders, stating that no excessive trouble has been encountered. Some engines use tangential oil sprays here, others use sprays of different lengths, one uses four horizontal and one vertical sprays. Expansion of cylinder liner and jacket on double-acting engines is generally taken care of by making the cylinder consist essentially of two single-acting cylinders end to end. Piston cooling has received much attention and investigations are now under way to determine causes of piston-rod breakage, which has sometimes occurred in these engines. Proper design, use of rough surface on inside bore of the rod, use of plating, stainless steel and nitrided rods are some of the steps being taken to prevent this.

Automatic Diesel Plants

The Present Position of the Automatic Diesel-Electric Plant was outlined by Edgar J. Kates, consulting engineer, in the next paper. This type of plant, one of which was installed at the Hotel Chelsea, New York City, in 1930, consists of several Diesel generating units operating in parallel with a storage battery and a battery booster, the whole installation controlled automatically.

Economic justification for automatic Diesel power plants, it is stated, is low cost of fuel combined with low cost of attendance.

Engines are started by using their generators as motors. Fuel pumps do not function until the engine is up to speed, when the governor takes control and the pumps start delivery. The generator is then connected automatically to the line. The engines are equipped with complete pressure lubricating systems, each engine having its own direct-driven lubricating-oil-pump. Automatic devices stop the engine if the lubricating oil pressure falls too low and prevent starting under the same conditions.

Each engine has its own fuel supply system, with a transfer pump and provision for supplying oil from a standpipe in the event of transfer pump failure. Jacket water temperature is kept constant under automatic control, much of the water being recirculated. A common exhaust line is desirable to save space and expense. In this case an automatic valve on each engine prevents exhaust from engines from backing up through the header. Engines obtain their combustion air from the engine room, which is supplied with filtered air. Advantages claimed for the automatic Diesel plant are: elimination of air-starting system with resulting reduction of cost; simplification of fuel-injection system and governor, because of constant speed operation, as the engine never runs at light load or idling; elimination of enclosures because the engines and auxiliaries run in closed rooms supplied with filtered air. Units are started or stopped in accordance with load, line voltage is maintained constant without flicker regardless of load surges and all supply services to the engine are fully controlled and safeguarded.

Discussing the Diesel Engine in Municipal Plants, C. F. Lambert of Burns & McDonnell Engineering Co., gave a tabulation of estimated costs for fifteen Diesel engine plants and then presented detailed data on several recent installations. Ponca City plant, for 1930, with four 1250 hp. engines showed an average of 10.3 kw-hr. per gal. of fuel oil and 1852 kw-hr. per gal. of lubricating oil. La Crosse, Kansas, showed for 10 yr. an average of 9.67 kw-hr. per gal. of fuel oil; the kw-hr. per gal. of lubricating oil decreased from 1170 in 1921 to 618 in 1930. Repairs and supplies for 10 yr. averaged 0.43 mills per kw-hr., total operating cost for plant and distribution system 1.21 cents per kw-hr. for the 10 yr. and 0.81 cents for 1930. Another group of engines averaged from 10.5 to 11.26 kw-hr. per gal. fuel oil with maintenance costs ranging between $0.00007 and $0.00138 per kw-hr. Data of a similar nature were given for several other well-known Diesel plants.

Light-Weight Engines

A Decade of Light-Weight Diesel Development in Europe was reviewed by John O. Huse, Bureau of Engineering, U. S. Navy Dept. His observations were based on a table giving the chief design factors of 40 modern four-cycle high-speed light-weight European engines designed by 17 manufacturers. The minimum size is 35 hp. per cylinder, the maximum 235 hp. None of the engines weighs more than 30 lb. per hp. complete. The following trends, the author stated, are sharply defined at present: vertical line cylinder arrangement, solid injection, aluminum uncooled pistons in cylinders up to 125 hp. and cast-iron or forged-steel cooled pistons above 125 hp., increased piston speeds, moderate brake mean effective pressures in unsupercharged engines, multiple inlet and exhaust valves and tie-rod framing construction. Other factors are controversial such as supercharging, use of aluminum in stressed members, use of individual fuel pumps or block pumps, open fuel nozzle or closed automatic nozzle, limiting size of the four-cycle cylinder and others.

Disregarding aircraft developments, the last decade has produced "a high-speed, four-cycle Diesel engine in outputs up to 120 hp. per cylinder, weighing but 20 lb. per hp., running at speeds of 600 to 1000 r.p.m. and occupying less than ½ cu. ft. per hp. . . . In the same period, the cost of the light-weight Diesel horsepower has been more than halved."

European Trends in Diesel Engines were also discussed by O. F. Allen, consulting engineer. The Verein Deutscher Ingenieure contributed a paper on Diesels for Motor Trucks. This session was presided over by L. B. Jackson of Fairbanks Morse & Co.

Marine Diesels

On the morning of the third day, with Harte Cooke, Engineer, McIntosh & Seymour Corp. presiding, the meeting heard a paper by A. J. C. Robertson of Fairbanks Morse & Co. on Marine Propulsion by Diesel Engines. The author discussed the details of engine design with reference to propeller size and efficiency, r.p.m., ship speed and other factors and showed curves of propeller performance and tabulations of the above factors.

In the next paper, Benedict J. Isidin, Engineering Dept. Aluminum Co. of America, pointed out that the speed of oil and gasoline internal-combustion engines has been brought into a higher range following the availability of improved materials and the necessity of obtaining increased power output without sacrificing

space and weight. This often makes it necessary to reconsider some points of design and to adopt better grades of material to solve the problems of higher heat stresses and increase in dynamic bearing loads. Therefore the piston is sometimes cast of steel in thinner section and the cylinder liner is made thinner and is cast of steel to reduce thermal stresses. Connecting rods are made of special alloy steels to withstand higher stresses than are allowed in plain carbon steel. As a satisfactory means of reducing the weight, the author discussed the use of aluminum, allowing heavier sections, preserving the rigidity and removing any thermal difficulties encountered in the piston.

Following this session, a trip was made to the Fairbanks Morse works at Beloit and in the evening a banquet, dance and party were held in Memorial Union.

Piston Packing

Piston-Packing Efficiency by C. E. Sencebaugh, Double Seal Ring Co., was the first paper at the Friday morning session, presided over by Edgar J. Kates. Increase of the mechanical efficiency of the oil engine is obtained by proper design of the piston packing, Mr. Sencebaugh pointed out. He covered the evolution of the piston ring and the design and construction of plain and multi-piece rings. Materials were compared and wear discussed with relation to piston speed, r.p.m., heat and pressure stresses and the position of the first ring. Quality, quantity and method of lubrication were covered as well as factors of operation such as temperatures, pressure on the rings and back of them and the initial ring tension.

The new municipal Diesel power plant at Carthage, Mo., was described in detail in a paper by C. Ruegg, chief Diesel designer, Nordberg Mfg. Co. This plant was built in 1927 and included Diesel units moved into it from an older plant, with the addition of a new unit and improved fuel storage, lubricating oil and cooling water systems. Cost records for the plant were shown and production costs analyzed.

Waste Heat Recovery

In a paper on Heat Recovery from Internal Combustion Engines, Thos. Clarkson, consulting engineer and Wm. Bradford, Director of Engineering, Edge Moor Iron Co., citing the heat losses of locomotives and steam turbines, pointed out that in the internal combustion engine two-thirds of the heat is wasted in exhaust gas and cylinder jackets. The need for further heat conservation is urgent. In considering the recovery of heat from exhaust gas the authors lay down seven basic conditions. Adding to these limitations the avoidance of back pressure and the provision of a simple way of decarbonizing the heating surface, the designing of the ideal waste heat boiler is not a simple matter. The evolution of the thimble tube boiler after 30 yr. of experience is described.

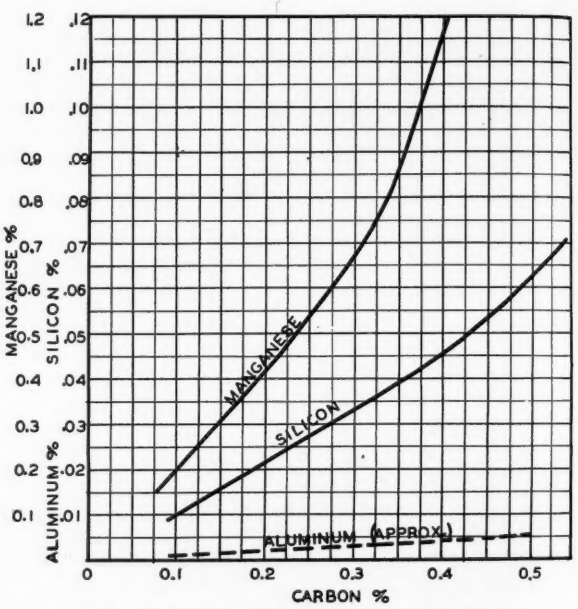
Following this paper, the meeting closed and special trips were arranged for the visitors to the Wisconsin Dells, to Milwaukee industrial plants and to the Grand Haven Diesel power plant.

Natural gas, when properly mixed with air at the burner, burns with a very short flame.

Steel for Good Welding

One stumbling block in the application of arc welding has been the porosity in the weld or deposited metal. What causes one weld to be solid, dense and free from porosity while the next will be porous? The answer probably is variability in the steel itself, as revealed by an extensive research conducted by Wilmer E. Stine of the Research Laboratories of The Lincoln Electric Co. His remedy is in the form of the Lincoln-Stine equilibrium curve, by which the specifications for steels of good weldability can be determined.

To determine the correct proportions of the elements in steel for best welding use the accompanying curve is used. For example, if steel having 0.20 per cent carbon is required, the curve shows that the silicon content should be approximately 0.021 per cent and



RELATION OF STEEL INGREDIENTS TO GIVE SOLID WELDS

the manganese 0.4 per cent. If the steel has been deoxidized in manufacture by the addition of aluminum, the amount of this element present should not be more than 0.002 per cent. Thus, for any required carbon content of steel, correct proportions of silicon, manganese and aluminum can be specified to insure steel of best welding qualities.

In conducting the research, Mr. Stine felt that for steels having improper proportions of elements for good welding, chemical equilibrium at the proper temperature might be brought about by the use of a corrective flux fused into the steel during the welding process. During the research, he developed fluxes for this purpose, so that if it is found that the composition of the steel on hand fails to meet the requirements indicated by the curve, in many cases the steel can be satisfactorily welded by using such a balancing flux.

To insure quick starting and smooth operation of Diesel standby plants, one company requires a minimum operation of 30 min. each week.

Installing Underground Cable

Special plow used for installing underground cables in locations where a minimum of disturbance to ground is desired.

BY MEANS OF A SPECIAL plow shown in Fig. 1, built by the General Electric Co., the plow being available for rental purposes, parkway or underground cable can be installed beneath sod and in locations where a minimum disturbance to the ground is desired. A reel of parkway cable is located at one end of the circuit run, and is mounted on supports so that it may unreel easily. The plow is connected to a tractor and one end of the parkway cable is connected to the plow blade (Fig. 2). The blade is started in the ground and, because of the nature of the blade point, there is opened a hole of sufficient diameter to permit the cable to be dragged through it. The surface of the earth is not disturbed except to the extent of the width of the plow blade as may be seen from Fig. 3.

The limit of the use of this type of installation is the mechanical strength of the cable. When the length to be installed becomes so great that the mechanical friction of the cable within the bore hole exceeds the tensile strength of the cable, it is necessary to cut this length and start a new one. This type of plow is readily used when installing parkway cable within the curb line of a street, around tree roots, poles, etc. The depth limit of the plow is 15 inches.

ELECTRICITY— What it is *and* How it Acts

Part LII

Final Considerations. The significance of waves in the Universe. Mathematics as a factor in explaining the nature of the world. Animate and inanimate matter. Life and the electron.

By A. W. Kramer

FROM THE EXPERIMENTS of Davisson and Germer in America and those of Thomson in England, it is quite evident that the essential truth of de Broglie's theory is firmly established; electrons are waves or at least they have waves associated with them. Startling as this may seem at first, this concept should not surprise us greatly; indeed, we might have suspected it. We know that light was possessed of a dual nature, so why not also the electron? As J. J. Thomson has pointed out[1] this duality of corpuscles and waves which is so much in evidence in many regions of physics may be the ultimate nature of things.

The electron, then, instead of being merely a point charge of electricity, seems to be possessed of a dual structure; one part, that in which the energy is located being built up of lines of electric force and the other part consisting of a train of waves in resonance with the electron. These waves determine the path along which the electron travels.

Although the essential truth of these waves seems established, their interpretation is a much more difficult problem. Their nature remains quite unknown but it is evident that they are different from ordinary light waves, for they are markedly influenced by electric and magnetic fields while light waves are not. Even the most powerful magnetic fields we can produce have absolutely no effect upon a ray of light or X-rays but a beam of electrons streaming across the vacuous space of the cathode ray tube is easily deflected by a small permanent magnet.

They differ from light waves also in another respect; their wave length or frequency varies with their speed. Light waves of course, all travel at the same velocity regardless of their frequency but electron waves necessarily move at the speed at which the electron moves. It has been found that the wave length decreases as the speed increases. In all instances, however, even for the slowest moving electrons, their wave length is very much shorter than that of ordinary light waves.

This much is known, but as to their nature—what they are made of, if anything, what their relation is to light waves, we know very little. But that there is a relation of some sort is quite evident for, as has been shown, under certain conditions electron waves seem to be able to be converted into light waves.

[1] "Beyond the Electron," published by the Cambridge University Press.

It is very difficult to form a satisfactory mental picture of all this; of these electron waves and light waves and their interaction, for in dealing with anything it is only human that we should try to picture things. But here we find that there is nothing that we can picture—merely a universe of waves—energy. Sometimes this energy manifests itself as matter, as electrons and protons; at other times, as radiation, and as long as we regard matter and radiation in the aggregate it is easy enough to differentiate them but when we resolve them both into their fundamental wave structure, we find our systems of classification of little value.

It is because of this impossibility of visualizing the phenomena that the mathematical theories of de Broglie, Schroedinger, Dirac and others have been so successful in explaining the physical nature of the universe, for the symbols and numbers upon which their theories are postulated represent the waves of light and the electron we have been trying to describe. In mathematics it is unnecessary to encumber our minds with clumsy analogies drawn from our own limited field of perception but we can proceed with the development of abstract concepts in an orderly and logical manner. This is a great convenience. In considering the question of energy transmission through space, it is sufficient merely to take account of the frequencies of the waves involved—it is unnecessary to invent a medium such as the ether for the waves.

In the same way, in dealing with the electron mathematically it is merely necessary to consider the quantities representing the frequencies involved, without its being necessary to build up a model of the electron which we can visualize.

As Professor Thomson has pointed out there is no actual necessity for any vibration of a material or quasi-material object. The essence of a wave is the transference of a "state" according to certain laws. The state may or may not be one of motion. On this view, the function of a wave is to produce conditions at the electron which oblige the electron to move along the instantaneous position of the wave normal (in the absence of a magnetic field) and along another, but determinate, direction in a magnetic field. The motion of the electron is determined not only by the wave in its immediate neighborhood, but also by the history of the whole wave front.

Perhaps the easiest way of looking at the whole theory is to regard the waves as an expression of the laws of motion. The uniform motion of Newton's first law is thus replaced by a simple plane wave. In this view, the electron remains a reality and this seems right; for after all, it is the electron as a particle that we actually detect in any conceivable experiment. The waves bear approximately the same relation to the electron as Newton's or Einstein's law of gravitation bears to the planet which obeys it.

And so we come to the end of our story. Little more remains to be said. The electron has served well and if, perhaps, some things are not as clear as we might desire to have them, on the whole it has provided us with an explanation of nearly all physical chemical and electrical phenomena. It accounts as readily for the heating of a wire connected to the terminals of a battery or generator as it does for the formation of sodium chloride from chlorine and sodium. Not only on earth but in the stars, the electron gives us an insight into things.

The fundamental relationship between the electron and various forms of electromagnetic radiation is proved by the quantum theory. This theory more than anything else has given us the clue to the all importance of the question of frequency, whether it be in the unlocking of the unlimited stores of energy in the atom or in the taking of a photograph with a vest pocket Kodak.

Red light we know because of its long wave length[2] (low frequency) has feeble quanta, while violet light is endowed with energetic quanta. We know that work which demands one powerful quantum can not be performed by two or indeed, any number of feeble quanta. In other words, a large amount of red (low frequency) light can not accomplish what a small amount of violet (high frequency) light can do—a fact, known only too well by every photographer. The tiniest ray of violet light will spoil an unexposed plate or film, but no amount of red light has any effect. As Jeans so aptly puts it, "the law prohibits the killing of two birds with one stone as well as the killing of one bird with two stones."

Frequency is the language of the universe. If we know the frequency of the radiation reaching us, we know what is happening at the source from whence these radiations come. Thus Millikan, in detecting radiation with wave lengths of 10^{-12} cm. coming from all directions in space, advances the idea that these radiations indicate the building up of complex atoms from simple ones. And from the Einstein equations giving the energy matter equivalent, we can form some idea as to just what atoms are being formed in this manner.

As a matter of fact, if we consider the whole gamut of electromagnetic radiation frequencies, from one to infinity, we are considering all physical, electrical and, who knows, probably all biological phenomena; for it will undoubtedly be shown that life itself is dependent in some way upon the electron and proton.

In our study of nature, we have seen fit to place all things into two classes, organic and inorganic—animate and inanimate. And so also with those who study nature; while her students are at one in their complete loyalty to her, they group themselves broadly speaking into two classes: those who study only the physical aspect of nature, the astronomers, the geologists, the chemists and the physicists and those who include in their view the phenomena of life, the biologists, the paleontologists, the physiologists and the physicians.

It has always been generally believed that the division between these groups is marked by one of the very few sharp lines of demarcation to be found in nature; the distinction between the animate and the inanimate. Other apparently sharp lines have been noted in the past, notably the distinction between organic and inorganic chemical compounds; but with the advance in our knowledge these have disappeared, leaving the life line as perhaps the only one which can still be regarded as tenable. But is even this line of demarcation to stand? At present it is still quite unassailable, but it is not entirely improbable that this last line of division will also be shown to be indefinite and that when reduced to their ultimate simplicity, there may be no marked distinction between living and nonliving things.

If life has sprung from the nonliving, its simplest forms must be exceedingly minute, and if we are to find the answer to the question anywhere it is probable we must look in those queer things which the bacteriologists call the "filterable viruses." These are living bacteria so exceedingly small that not only are they invisible in the finest microscopes at our disposal but they pass easily through the minute pores of fine unglazed porcelain filters. Such are the bacteria responsible for the disease we call smallpox.

In a similar class are certain bacterial cultures, discovered by D'Herelle, called "bacteriophage" which seem to be excessively minute organisms which prey on ordinary bacteria in the same way that ordinary bacteria do on man.

While the correctness of this idea remains unsubstantiated, it is interesting to know that methods for rendering such minute organisms visible, have been developed recently at the Institute for Colloid Research at Frankfurt. The process described briefly by Donnan in the Annual Report of the Smithsonian Institution for 1929, consists in depositing gold on them, strengthening up these gilded individuals as one enlarges the silver particles in an insufficiently exposed negative and obtaining as the end result a sort of metallic skeleton of the original organism. It appears that D'Herelle's bacteriophage are small disks having a diameter of from $35\mu\mu$ to $100\mu\mu$. ($A\mu\mu$ (milli-micron) = 1 millionth of a millimeter. The diameter of an ordinary chemical molecule is about $1\mu\mu$.)

Now, colloid[3] particles are considerably larger than that, and if it can be proved beyond all doubt that they are really living organisms, then the individuals of D'Herelle's bacteriophage are comparable in size with the known colloid aggregates of nonliving matter.

This gives rise to strange hopes. If we can find a complete continuity of dimensions between the living and the nonliving, is there any point where we can say that here is life and there is not life?

What a strange story! A universe of waves—waves

[2]The quantum is proportional to the frequency of radiation and so is universally proportional to the wave length.

[3]A colloid is a state or subdivision of matter which consists either of single large molecules (proteins etc.), or of aggregations of smaller molecules (gold, etc.). These particles of ultramicroscopic size may be solid, liquid or gaseous and are surrounded by different matter which may also be solid, liquid or gaseous. They are nonliving—the size and electrical charge of the particles determining the different phenomena observed with colloids.

which have no significance to the human mind except as their frequency can be expressed by numbers. Waves of one number (frequency) mean light, vision, color, beauty, photography; waves of another number mean sound, noise, music, harmony, pain, destruction, waves of still other numbers, mean organic growth, feeling, sense of touch, taste, smell, warmth and probably also love, hate, fear and pity. No matter in which direction we go or what we contemplate, always we find that the object of our interest can be expressed in terms of numbers—waves. Whether it be an X-ray or a kiss the ultimate explanation of the thing lies in the frequency of its vibration. All we know, all we hear or see comes to us through the agency of these vibrations.

The marvel of the thing is that these concentrations of atoms and molecules we call ourselves have an insight into the mechanism of the vibrations. For, after all, we are but an infinitesmal speck in this vast universe of waves. On the cool surface of a tiny planet, warmed by the rays of a declining star, we stand, together with other living things—green meadows, trees, flowers, beasts, birds, fishes and microbes—covering but an infinitesimal fraction of the earth's surface. Yet it is the mind of man that has penetrated the cosmos and discovered the distant stars and nebulae, and that has penetrated far into the atom. Life has gone far in developing from a tiny speck of protoplasm into a thing with a mind. Who knows to what length this new thing, this mind, this soul, if you will, may carry us. If at present our study of the electron stops where life begins, who can say that this need always be so? Some day, perhaps some gifted genius, with an infinite insight into the nature of things, will discover that the electron is not only the basis of all inanimate matter but also of animate matter. Truly, then, we may say that life is the great mystery and the study of life the greatest of all studies.

The End.

EDITOR'S NOTE: In presenting the concluding article of the series Electricity—What It Is and How It Acts, we wish to direct attention to the fact that the entire series will be available in book form. The first 25 chapters have already been published as Volume I while the remaining 27 chapters will appear as Volume II early next fall.

New Boiler Plant Built at Gatineau

CANADIAN INTERNATIONAL PAPER CO. BUILDS A NEW BOILER PLANT WITH FOUR 13,400-HP. BENT TUBE BOILERS FIRED BY PULVERIZED COAL

EXPANSION and increasing demand for process steam made it necessary for the Gatineau (Quebec) Plant of the Canadian International Paper Co. to supplant its electric boiler capacity with coal fired boilers. The new plant built adjacent to the electric boiler room has four 13,400-sq. ft. Kidwell boilers with a normal capacity of 117,000 and a peak capacity of 130,000 lb. of 200 lb., 60 deg. F. superheat steam per hour. Except for a small amount taken by the steam turbines driving the paper machine, the steam is used for process work and a high superheat is neither necessary or desirable. The boiler is baffled for three passes with a small con-

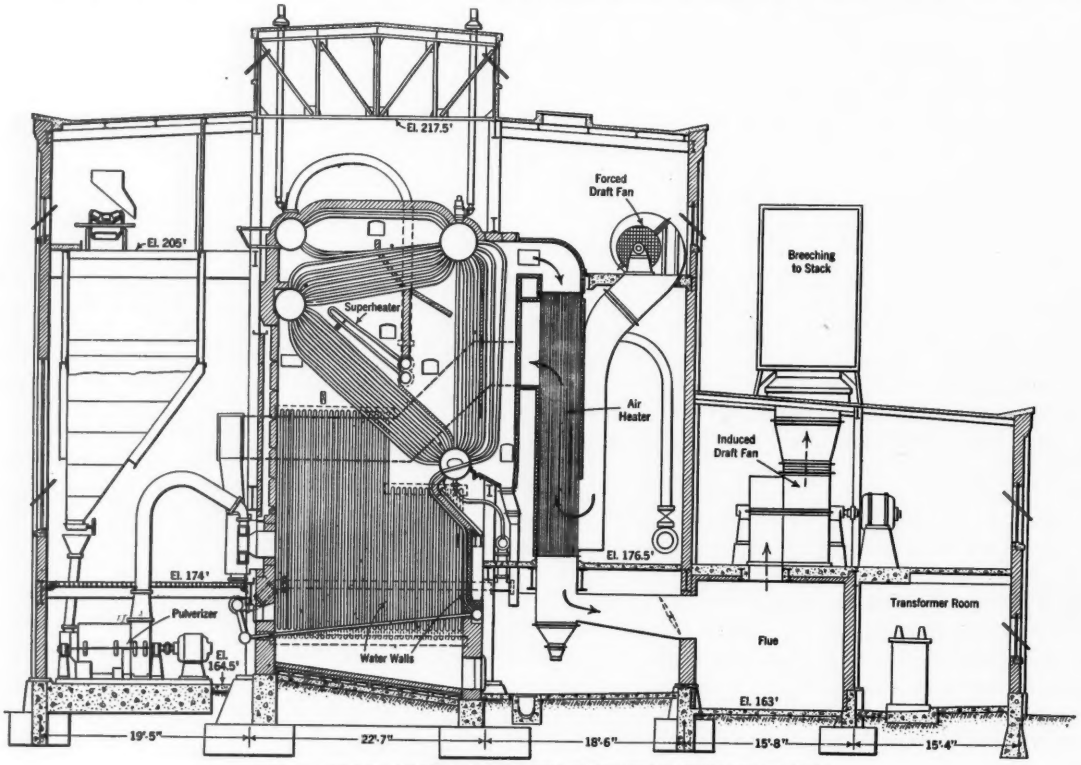


FIG. 1. CROSS SECTION OF THE GATINEAU BOILER PLANT

List of Equipment, Gatineau Plant

4 Kidwell Boiler Co. 13,400-sq. ft., 200-lb. 3-pass bent tube boilers 40 tubes wide, normal capacity 117,000 lb. per hr., peak capacity 136,000 lb. per hr.
4 Foster Wheeler Co. convection superheaters.
4 Foster Wheeler Co., 70,800-sq. ft. tubular air heater, 1134 2½-in. tubes 42 tubes wide, 27 tubes deep.
12 Foster Wheeler Co. Aero pulverizers, 8 with a capacity of 7000 lb. per hr., 4 with a capacity of 3500 lb. per hr. Pulverizers driven by 150 and 175-hp., 1150-r.p.m. variable speed slip ring motors
12 Foster Wheeler turbulent burners.
4 Foster Wheeler furnaces and water walls; furnace volume, 6600 ft., wing back construction, side walls, 427 sq. ft. each; rear wall, 280 sq. ft.; water screen, surface 189 sq. ft., made up of 20, 3¼-in. tubes.
4 M. H. Detrick Co. air-cooled front walls.
4 B. F. Sturtevant Co. double inlet forced draft fans each with a capacity of 50,000 c.f.m. at 8 in. static pressure driven by 100-hp., 1150-r.p.m., variable speed, slip ring motors.
3 B. F. Sturtevant Co. single inlet induced draft fans with bolted wheel construction and renewable cast iron liners in casing, each with a capacity of 135,000 c.f.m. at 5½ in. static pressure and driven by 250 hp. 600 r.p.m. variable speed slip ring motors.
1 H. R. Heinicke, Inc., 15-ft. diameter, 200-ft. high, radial brick chimney.
1 Canadian Vickers, Ltd., coal bunker with a capacity of 175 t. per boiler.
1 Link-Belt Co. 24-in. belt conveyor.
1 R. H. Beaumont Co. 140-t. per hr. double bucket balanced skip hoist.
1 R. H. Beaumont Co. 5000-lb. movable back post drag scraper.
1 American Pulverizer Co. 140-t. per hr. ring type crusher.
1 Ingersoll-Rand Co. 1200-g.p.m. recirculating ash sluice pump.
1 Allen-Sherman-Hoff Co. hydrojet ash sluice system.
1 Mead Morrison Co. stiff leg derrick with double drum, electric hoist and 1-cu. yd. clam shell bucket.
1 Ingersoll-Rand Co. 6-in., 2-stage boiler feed pump driven by a Terry steam turbine.
4 Ferranti Elec. Co. 700 kv-a. single-phase, water-cooled 6600/550-v. transformers.

Boiler settings	Atwood, Ltd.
Feedwater regulators, S-C	Swartwout Co.
Soot Blowers	Vulcan Soot Cleaner Co.
Blowoff valves, Yarway	Yarnall-Waring Co.
Safety valves	Consolidated Ashcroft Hancock Co.
Boiler meters	Bailey Meter Co.
Draft Gages	Bailey Meter Co.
CO_2 recorders, Ranarex	Permutit Co.
Recording thermometers	Bristol Co.
Flow meters	Republic Flow Meters Co.
Ducts and breechings	Foster Wheeler Co.
Insulation	Atlas Asbestos Co.
Coal scale	Merrick Scale Co.
Car puller	Silent Hoist, Winch and Crane Co.
Piping	Crane Co.
Valves	The Edward Valve & Mfg. Co. Jenkins Bros., Ltd. Walworth Co.
Fittings	Walworth Co.
Vacuum cleaner	Allen and Billmyre Co.
Continuous blowdown	Henszey Deconcentrator Co.
Motors	Crompton-Parkinson General Elec. Co.
Oil switches	Westinghouse Elec. & Mfg. Co.
Concrete piling	Raymond Concrete Pile Co.
Grating floors	Irving Iron Works Co.

vection superheater above the first bank of tubes and a tubular air heater behind the boiler. Each boiler has an individual forced draft fan and the flue gases discharge to a common flue on the ground level from which it is taken by three induced draft fans and delivered to the stack.

Air heaters are expected to reduce the flue gas temperature from 625 deg. to 340. deg. F. and heat the air

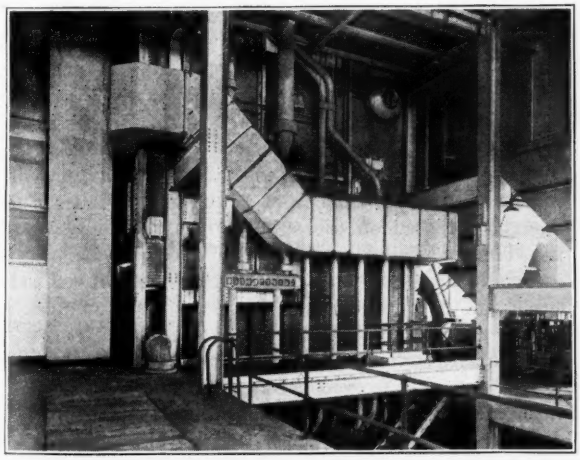


FIG. 2. ONE OF THE BOILER UNITS, THE SPACE IN THE FOREGROUND AVAILABLE FOR THE INSTALLATION OF A FIFTH UNIT

for combustion from 70 to 415 deg. F. It is estimated that the boilers will have a continuous overall efficiency during normal operation of 82.5 per cent.

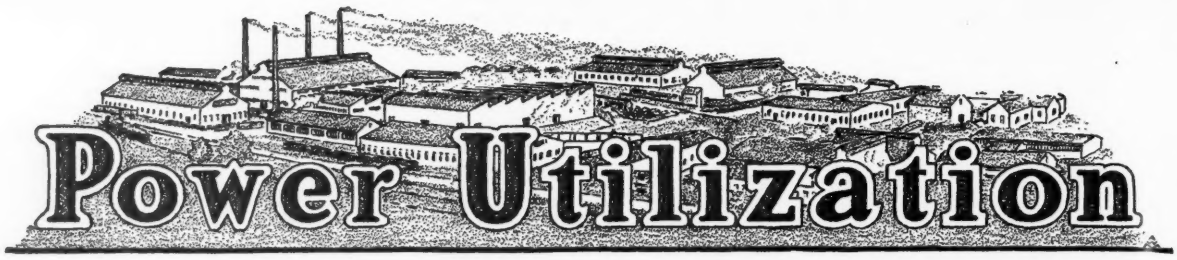
Overhead bunkers feed three pulverizers for each boiler. The pulverizers are located on the ground level below the operating floor. Two units have a capacity of 7000 lb. of coal per hr. and the third, intended to carry the light week-end load, has a capacity of 3500 lb. per hr. Each pulverizer discharges through a single turbulent type forced draft burner, to the 6600-cu. ft. furnace which is designed for heat liberation of 22,600 B.t.u. per cu. ft. per hr. at maximum rating.

Two side walls and the rear wall are water-cooled with a slag screen consisting of 20 tubes located about 5 ft. above the furnace floor. The volume of the furnace below the screen is about 1800 cu. ft., which allows several days' accumulation of ash before removal is necessary. The front wall and furnace floor is air-cooled. The plant contains the four largest steam generating units in the Dominion of Canada, but because of the ash removal system and the induced draft fan arrangement adopted, the boiler room requires no basement and is only of moderate height. Over all dimensions are 51½ ft. high, 61 ft. wide, 193 ft. long, which includes sufficient space for the installation of a fifth boiler.

This company is a subsidiary of the International Paper Co. The new plant was designed and constructed by the company's own organization.

ON THE FLATHEAD RIVER, five miles below the outlet of Flathead Lake in Montana, the Rocky Mountain Power Co., a subsidiary of the Montana Power Co. is now working on the diversion of the river through a 1700-ft. tunnel. The project will utilize Flathead Lake as a regulating reservoir by means of a dam, which will submerge the present lake outlet. The dam will be 200 ft. high and 630 ft. long, including 400 ft. of overflow spillway.

Penstock tunnels 870 ft. long through the ridge in the foreground will conduct the water to the power house. It is proposed to install three 50,000-hp. units which will operate under a head of 185 ft. when the lake is full.



Anti-Friction Bearings and the Power Bill

By L. M. Klinedinst*

OFTEN LATELY it has been remarked that those industrial plants which take advantage of the present situation to modernize will reap much benefit in the future. It is also quite generally understood that the term, modernize, means nothing more or less than reorganization of plant equipment and methods with the single end of increasing production economy. Naturally, the angles from which the problem can be attacked vary in every plant; there is one, however, that is practically common to all of them—the item of power consumption. It is true that, in many cases, the power bill is apparently of secondary importance as an item of production cost but it is equally true that, in other cases, it offers about the best opening for reducing expenses, as, for example,

FIG. 1. ANTI-FRICTION BEARINGS IN A STEEL MILL REDUCE FRICTION UP TO 40 PER CENT

in certain types of industries labor and materials offer little if any opportunity for saving, while the power situation does. It is perfectly safe to say that, in any case, reducing power expense is well worth consideration, no matter how apparently unimportant the saving may be.

Reduction of Friction Possible in All Plants

It is logical that any consideration of means for saving power should focus attention on anti-friction bearings, since that is their primary function. During the past few years, the anti-friction bearing has made great strides in development, until now there is practically no type of industrial plant that cannot take advantage of its possibilities. Few classes of machinery have not been anti-frictionized thoroughly, so it is perfectly consistent with probability to say that, the more completely a plant is anti-frictionized, the greater the benefit will be. Of course, the details of improvement will vary with the type of plant, according to the demand characteristics of the equipment used. That is, the individual savings in a steel rolling mill, for example, will be greater than those in a machine shop. But, on a basis of relative total plant load, the chances are that the savings will be much on a par. How this works out in practice can probably best be seen from a few concrete instances, which also serve to show what is actually being accomplished in the way of power savings, individually and in total.

In a Steel Mill

Since what are probably the most spectacular results have been achieved in steel mills and particularly with rolling mills proper, they should make a good starting point. Before discussing the results, it might be interesting to consider some of the factors that have contributed to them. Without going into the mechanical details as to why, it is a fact that ordinarily the rolling mill is one of the most prolific sources of power wastage known to industry. Normal loads are high and are complicated by successive sustained peaks, also an inordinate starting inertia. In consequence, mills have to be heavily over-powered, resulting in a poor load factor for the mill and maximum demand conditions that are exceedingly undesirable. In fact, it can and often does happen that rolling can be done only in off-peak hours because of the demand imposed on the supply lines. Some years ago the Timken Roller Bearing Co. developed a bearing especially for steel mill service that has proved fully successful in practice. The company was fortunate in having a steel mill of its own, which served as a development laboratory for the bearings, consequently, they were thoroughly proved before any outside applications were attempted. From the standpoint of the present discussion, probably its most interesting feature is the effect on mill power demand.

This is attributable to several causes. In the first place, the normal demand is lowered by the reduction in the friction component of the load. Second, peak loads are reduced in volume and, to some extent, in duration. Finally the starting inertia is brought down to a point where maximum demand practically ceases to be a factor in operation. As a result, it has been proved by experience that savings in power between 30 to 40 per cent can be expected as a matter of course. Where con-

*Vice-President, The Timken Roller Bearing Co.

ditions were exceptionally severe, the savings have amounted to 60 per cent of the overall demand. The matter goes further than power savings; the load factor of the mill as a whole is decidedly improved, since usually the rolling mills make up the greatest part of the connected load.

It might be said, before leaving the subject, that the opportunities for anti-frictionization in this type of plant by no means stop at the rolling mills. Bearings have been successfully applied to much of the accessory equipment,—run out table rollers, cranes, and a number of process machines, such as straighteners, hot and cold saws. While individual savings may not bulk as large as those effected on rolling mills proper, in the aggregate they will produce a marked reduction in the power requirements. Another matter that is worth mention, the maintenance costs are also radically reduced, which is important in steel mills, where, ordinarily, bearing maintenance forms a decidedly large item in operation. So, to sum up, complete anti-frictionization of steel mills means, to the operator a higher tonnage per kilowatt-hour and, to the central station, a steadier, hence, much more desirable load.

Clay Plant Friction

At the beginning it was said that in some varieties of plant the power bill offers the best opportunity for retrenchment in production expenses. What may be called, generically, brick and clay plants are a shining example. Generally speaking, labor, raw material, investment and fixed charges are, in plants of comparable size, much the same. But it so happens, as with steel mills, that the machinery used in such plants, either individually or in bulk, is characterized by high friction loads, which means proportionately heavy power demands, not to mention a fairly high percentage of power wastage. Now, experience has shown that anti-frictionization of the heavy duty machines that are an integral part of every clay plant's equipment reduces their power requirements anywhere between 25 and 30 per cent, while the savings effected in the case of some of the accessories, conveyors and material handling equipment generally, are comparable. It follows, logically, that the complete anti-frictionization of a plant should produce noticeable results.

It does, as the record of two particular plants will prove. The first one is quite large, as such plants go, having a capacity of 150,000 brick a day. Circumstances recently caused a thorough revision of its equipment, when the opportunity was seized of anti-frictionizing completely. As a result, although the plant has now a greater capacity than formerly, the present connected load amounts to 1250 hp. as against a former 1500 hp. The daily power saving amounts to between 150 and 200 kw-hr. In addition, the overall power factor of the load was raised to a point between 0.9 and 0.95, and kept there, by using synchronous motors on some of the heavier machines. In the other case, the plant, not quite so large, was, nevertheless, sufficiently large to form a creditable example of what can be done by anti-frictionization. It also was completely changed over, with the result that there was a 20 per cent saving on a total load demand of 350 kw. In each case, both sides were benefited by the change; the operator by the reduction in his power bill and the central station by the stabilization of the load. As an interesting example of what happens when a single machine is anti-frictionized, thus indicating why complete plant anti-frictionization has such drastic effects, in a particular instance, a single brick machine was changed over to anti-friction bearings, with a resultant drop of more than 25 per cent in its power consumption.

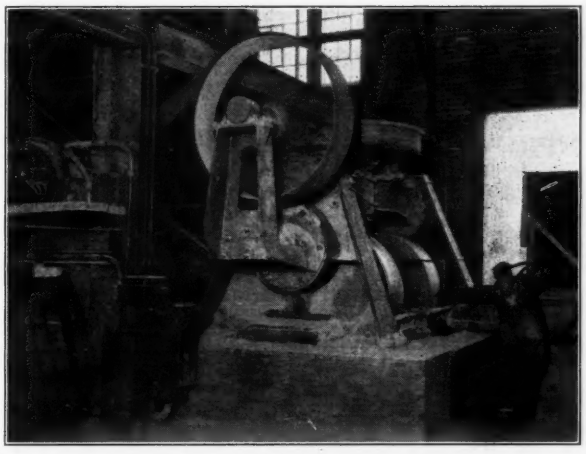


FIG. 2. 25 PER CENT SAVED IN FRICTION OF THIS BRICK PLANT MACHINE

Like Results for Smaller Machinery

It is always possible to say that, while these two examples may be interesting, they are too specialized to give a true idea of the general situation. This does not, however, necessarily follow. To take the other extreme, the power saving on the average machine tool due to anti-frictionization, on one tool the saving may appear unimpressive because of the comparatively small power demand of the tool but, on a hundred or more tools, it can be quite impressive. And that number is by no means unusual even in a moderate size factory. In other words, the matter resolves itself into balancing the large individual savings on a few heavy machines against the small individual savings on a large number of lighter machines. In the end, it will come to about the same

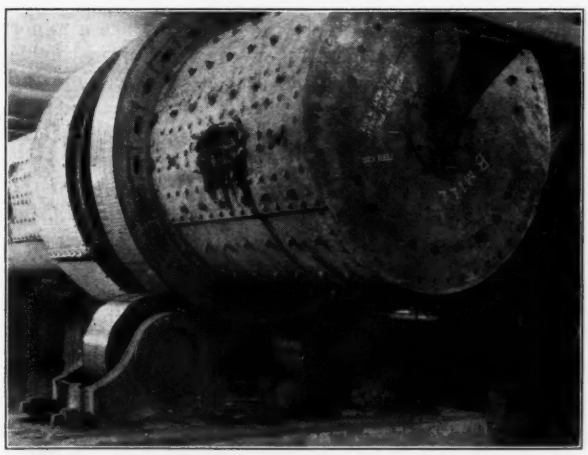


FIG. 3. IN A CEMENT PLANT BALL MILL, FRICTION IS WORTH REDUCING

thing. In fact, it would be simple but it is hardly practical, to go through one industry after another, quoting examples of what anti-frictionization has done to power bills. The stories would be much the same in general tenor as those of the "extreme" instances given above. As machines get lighter, the individual increments of saving become less, but the number of machines per installation goes up, thus preserving the average.

Conveyor Requirements Reduced

To argue from the particular to the general for a change, certain classes of machinery more or less common to all industries offer excellent mediums for showing how anti-friction bearings can affect power requirements. Prominent among these are the various types of material handling equipment, especially conveyors: Of

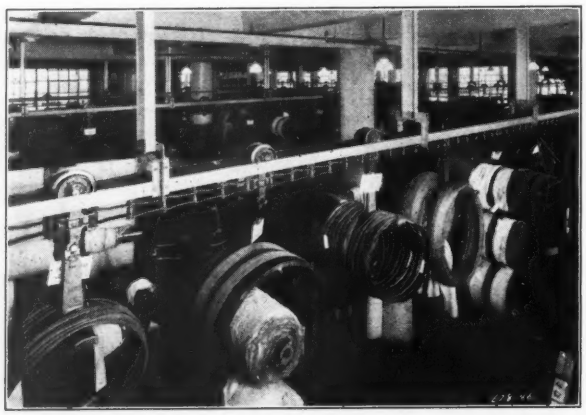


FIG. 4. ANTI-FRICTIONIZING AN OVERHEAD CONVEYOR REDUCES POWER AND STRESSES ON EQUIPMENT

the different types, the belt conveyor is probably the most illuminating example, for much the same reason that the steel mill is among production machines; that is, the belt conveyor is primarily a heavy friction load and its starting requirements are exceedingly severe on the driving motor. Consequently, conveyors are usually considerably over-powered, the motor selection being based more on the starting than the running requirements. In cases such as sand or gravel plants, where belt conveyors form the great majority of the installed equipment, these characteristics mean disproportionate power expense. Even where the conveyors are a minor part of the establishment, they cause an unjustifiable waste of money, unjustifiable because anti-frictionizing the conveyors changes the face of affairs completely. Not only is the overall power requirement reduced 20 per cent or more, but the starting torque required is brought well within the rated overload capacity of the motor, so that, in addition to actually saving power, the power factor is improved, to the advantage of everyone concerned. The same is more or less true in the case of other types of conveyors, whether they be pan, or flight, or overhead. All have the same characteristics as belt conveyors but not always to such a marked degree. To make a long story short, the anti-frictionizing of any variety of power-driven material handling equipment will prove a distinct advantage.

And so on. To tell the complete story of the effect of anti-friction bearings on power requirements in any reasonable space is an impossible task, not because of lack of material but rather because of an embarrassing wealth of it. As has already been intimated, the anti-friction idea has pervaded industry so thoroughly that the name of bearing applications is legion and the results are of a monotonous uniformity. It has been said rightly that the part played by the anti-friction bearing in making the development of modern machinery possible is hard to overestimate. One thing is certain, it is becoming most intimately connected with the burning question of obsolescence. Assuming the correctness of the following definition of obsolescence, the connection is quite obvious. A machine may be considered obsolescent when a new one on the same work will pay back the differential between its cost and the capital value of the old machine in a reasonable length of time. The payment is, of course, in the form of savings of one sort or another, reduced spoilage, a better production rate, or a saving in power. A machine that will, because of the anti-friction bearings with which it is equipped, save anywhere from 10 to 40 or more per cent on its power bill can hardly be considered obsolescent in any sense of the word.

This discussion having been practically confined to the power-saving phase of the situation, there has, deliberately, been little mention of the other benefits that follow a thorough policy of anti-frictionization, many as they are. The anti-friction bearing is not a panacea for every form of mechanical evil but, properly selected and applied, it will eliminate many of them. In any given case, the key to its success lies in proper selection and application. But that is another story.

Belt Conveyor Horsepower and Tension

FOR BELT CONVEYORS, taking into consideration the weight of the belt, the following formula from the Link-Belt Co., Chicago, gives the horsepower required to drive:

$$HP = (KL \div 1000) \times [T + (SB \div 16)] + (TH \div 990) + P$$

In this formula,

K and P are constants from Table I.

L is conveyor length between pulley centers, in ft.

T is tons of material per hr.

S is belt speed, ft. per min.

B = Lb. per ft. weight of belt from Table II.

H = Vertical lift of conveyor, in ft.

TABLE I. CONSTANTS

Width of Belt	Value of "K"		H. P. For Tripper, "P"	
	Plain Brgs.	Anti-Frict. Brgs.	Plain Brgs.	Anti-Frict. Brgs.
12	.149	.070	.75	.50
14	.144	.070	1.00	.75
16	.140	.070	1.00	.75
18	.135	.069	1.50	1.25
20	.132	.066	1.50	1.25
24	.125	.062	1.75	1.25
30	.117	.057	2.50	1.75
36	.109	.054	3.00	2.50
42	.102	.051	4.00	3.00
48	.097	.048	5.00	3.25
54	.092	.047	6.00	5.00
60	.090	.045	7.00	6.00

To the power as calculated from the formula, add for head and foot shafts; 20 per cent for conveyors 50 ft. or less in length; 10 per cent for length 50 to 100 ft.; 5 per cent for length 100 to 150 ft. Add for countershaft drives 10 per cent of total power for each speed reduction, if through cast tooth gears; 5 per cent for each reduction, if through cut gears.

From the above will be found the power for operation. A conveyor should not be started under load but,

if that is unavoidable, a motor of high starting torque or slip ring type should be used, or one of size increased to take the additional starting load. The larger motor will run at low load and power factors when operating steadily, hence at lowered efficiency.

Having the horsepower required, the effective pull on the belt in pounds is: $E = Hp \times 33000 \div S$

This is the difference between belt tensions on tight and slack sides, or $E = T_1 - T_2$.

The ratio of T_1 to T_2 depends on the coefficient of friction between belt and pulley and on the arc of contact of belt on the pulley but is independent of the size of pulley used. What is wanted is a maximum value of $T_1 - T_2$ with minimum values of T_1 and T_2. The ratio of T_1 to $T_1 - T_2$ is constant and, as $T_1 - T_2 = E$, the ratio of T_1 to E will be a constant C for a given set of conditions but any change which will increase the coefficient of friction or the arc of contact will lower the ratio of T_1 to E, hence reduce the maximum stress in the belt to secure a needed effective pull.

Values of $T_1 \div E = C$ for some typical drives are

TABLE II. APPROXIMATE WEIGHT, LB. PER FT., 28-OZ. DUCK RUBBER CONVEYOR BELT

Ply of Belt	Thickness of Top Cover Inches	Width of Belt, Inches											
		12	14	16	18	20	24	30	36	42	48	54	60
3	1/32	1.27	1.48	1.69									
	1/16	1.51	1.76	2.01									
	1/8	1.99	2.32	2.65									
	3/16	2.46	2.88	3.28									
4	1/32	1.55	1.78	2.05	2.33	2.56	3.08						
	1/16	1.78	2.08	2.37	2.67	2.96	3.56						
	1/8	2.27	2.64	3.01	3.39	3.77	4.53						
	3/16	2.75	3.19	3.64	4.09	4.54	5.46						
5	1/32	....	....	2.41	2.71	2.99	3.61	4.49					
	1/16	....	....	2.71	3.05	3.41	4.07	5.09					
	1/8	....	....	3.36	3.78	4.20	5.04	6.30					
	3/16	....	....	4.00	4.50	5.00	6.00	7.50					
6	1/32	....	....	....	....	3.44	4.13	5.06	6.19	7.22	8.42		
	1/16	....	....	....	....	3.84	4.61	5.76	6.92	8.06	9.4		
	1/8	....	....	....	....	4.64	5.57	6.96	8.35	9.75	11.4		
	3/16	....	....	....	....	5.44	6.54	8.16	9.80	11.42	13.35		
7	1/32	....	....	....	....	....	....	5.85	7.02	8.20	9.36	10.52	
	1/16	....	....	....	....	....	....	6.46	7.75	9.04	10.32	11.60	
	1/8	....	....	....	....	....	....	7.66	9.18	10.80	12.23	13.76	
	3/16	....	....	....	....	....	....	8.86	10.62	12.38	14.15	15.92	
8	1/32	....	....	....	....	....	....	....	7.82	9.14	10.40	11.70	13.00
	1/16	....	....	....	....	....	....	....	8.55	9.96	11.38	12.78	14.22
	1/8	....	....	....	....	....	....	....	9.97	11.63	13.30	14.95	16.62
	3/16	....	....	....	....	....	....	....	11.40	13.31	15.21	17.12	19.00
9	1/32	....	....	....	....	....	....	....	....	10.08	11.52	12.96	14.40
	1/16	....	....	....	....	....	....	....	....	10.92	12.48	14.03	15.63
	1/8	....	....	....	....	....	....	....	....	12.60	14.40	16.20	18.00
	3/16	....	....	....	....	....	....	....	....	14.28	16.32	18.36	20.40
10	1/32	....	....	....	....	....	....	....	....	....	12.65	14.15	15.80
	1/16	....	....	....	....	....	....	....	....	....	13.60	15.30	17.16
	1/8	....	....	....	....	....	....	....	....	....	15.56	17.50	19.40
	3/16	....	....	....	....	....	....	....	....	....	17.50	19.65	22.00

Link-Belt

NOTE—The weight of 32 oz. duck rubber covered conveyor belting is 1/7th heavier than weights.

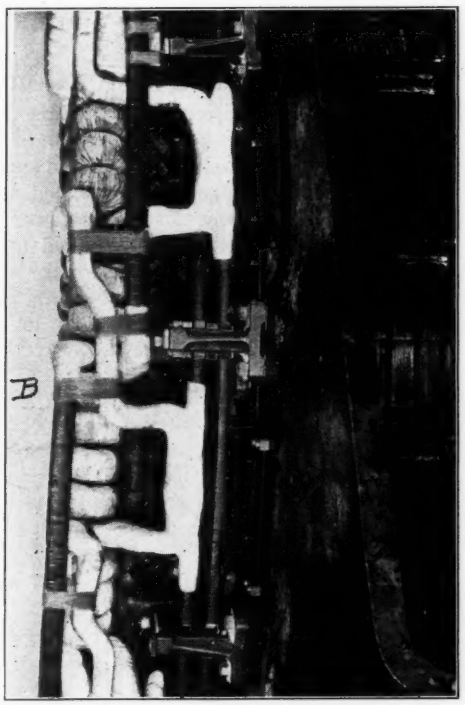
as follows: For 180 deg. contact on plain drive with bare pulley, 1.85; with lagged pulley 1.50. For snubbed drive with idler, 200 deg. contact, bare pulley, C = 1.72; lagged pulley, C = 1.42. Snubbed drive, 220 deg., bare pulley, C = 1.62; lagged pulley, 1.35. Snubbed drive, 240 deg., bare pulley, C = 1.54; lagged pulley, 1.30. For tandem drive, contact 360 deg. on two bare pulleys, C = 1.26; on lagged pulleys, 1.13. For 400 deg., bare pulleys, C = 1.21; lagged pulleys, 1.09. For 450 deg., bare pulleys, C = 1.16; lagged pulleys, 1.07. For 500 deg., bare pulleys, C = 1.13; lagged pulleys, 1.05.

Maximum belt stress, T_1 for good practice is given as 20 to 24 lb. per ply per inch of width for 28-oz. duck; 24 to 27 lb. for 32-oz. duck; 30 lb. for 36-oz. duck. For heavy drives with large pulleys, snub or idler pulleys are generally used to permit lower tensions and relieve strain on the first return idler.

Group Connector Support

By A. C. Roe

AFTER installing the coils in the stators of large motors, the leads must be properly connected. On modern machines the conductors are of large size and carry considerable current, hence the group connectors must be securely fastened to prevent movement during operation.



GROUP CONNECTION SUPPORTS

Numerous methods and schemes are used to brace the group connections, one neat method being shown. The heavy scrap copper rings or long jumpers are supported by special brackets as at A attached to the motor frame, at equidistant points. The shorter jumpers are well insulated then separated with several thicknesses of treated fullerboard, and two, three or more jumpers tied together with a cord band as shown at B.

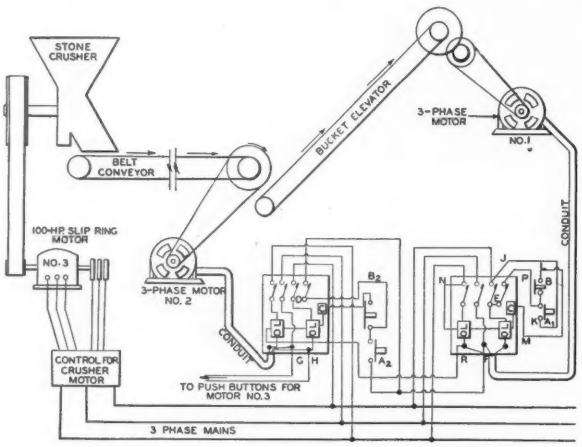
On the finished winding a number of coats of a high grade varnish are sprayed, which also helps to bind the group connectors together.

Close examination of the photo will reveal the use of two large steel tie rings, C and C, held in place by steel arms fastened to the frame. Two of these rings are at each end of the winding and each coil is roped to both rings. In addition the coil ends are further braced by tying the ends of adjacent coils together.

When inspecting or cleaning a large modern a. c. machine, the condition of the bracing should be checked to detect looseness of any part of the winding or connections, as a loose winding means movement of the coils which in turn leads to breakdowns unless remedied.

Electrically Interlocked Motor Controls

SOME TIME ago the writer installed three motors operating a stone crusher, a belt conveyor for the crushed stone and a bucket elevator which disposed of the crushed stone in a storage bin, all located approximately as shown in the sketch. The stone flowed in the direction of the arrows. As originally wired up, each motor was individually controlled by cross-line starters by means of push buttons and were not electrically interlocked. We learned to our sorrow that in case a



MOTORS 3 AND 2 STOP IF 1 STOPS AND STARTING CAN ONLY BE IN THE ORDER 1, 2, 3

motor stopped because of the overload relay functioning, the remaining motor or motors, continued to operate and the crushed stone would pile up at the bottom of the crusher or in the pit at the foot of the bucket elevator and it was then a heart-breaking job to dig out this material and get started again.

The wiring was then changed as shown in the accompanying sketch. Motors 1 and 2 are squirrel-cage induction, three-phase; motor 3 is a three-phase, slip-ring motor. Note that the jumper marked E on the control for motor 1 was not disturbed but the one formerly on the starter for motor 2 was removed as shown at D. Neither motor 2 nor 3 can be started until 1 is running nor can 3 be started until 2 is running. Also when the three motors are in operation, and 1 stops for any reason, the other two motors stop also, while in case 2 stops, 3 will also stop. This is due to the fact that the control on motor 2 must come from the motor leads of motor 1 and likewise, the control circuit for motor 3 is through the motor leads of 2.

The control circuit for motor 1 is as follows: Control current can flow by way of J-K-B1-L-M, through closing coil C, through the trip contacts on the overload relays, OL and back to the other side of the line via N. This closes the cross-line starter and when the start button A is released, jumper E and the wire marked P take the place of J and K, so the contactor remains closed. Motor 2 can then be started, as energy for operating the contactor is available via wires marked R and F, both of which are energized when motor 1 is running. Similarly G and H allow motor 3 to be started when 2 is in operation. Should motor 1 stop, wires R and F are dead and motor 2 stops, likewise 3 stops when wires G and H are dead.

The control for motor 3 is not shown in detail but is similar to that of the other two motors except that it is designed for starting a slip-ring motor, with resistors in the secondary circuit which are gradually short-circuited by contactors and a time relay as the motor comes up to speed. This control also has a start button and a stop button so the motor can be stopped without interference from the other motors.

Since making these wiring changes, no further trouble has been experienced and delays are now unknown.

Cold Spring, Minn. CHAS. A. PETERSON.

Refrigeration Calculations

IN ONE GALLON of brine a change of 1 deg. per min. in temperature is called a gallon degree; for instance, if 10 gal. of brine is cooled 10 deg. in 10 min., this is said to be 100 gal. deg. The gallon degree will not indicate a definite B.t.u. content, because the specific heat of the brine decreases as the specific gravity increases; but for brine of a known specific heat, the value of the gallon degree may be determined.

For a given brine system the value of the gallon degree is easy to calculate. The gallon degrees equal to 1 t. of refrigeration in 24 hr. must be taken into consideration and used as the basis as will be explained later.

Water weighs 8.35 lb. per gal. and by definition has a specific gravity and specific heat of one. The B.t.u. per min. equal to a gallon degree of brine is found as follows:

$$G = 8.35 \text{ lb.} \times g \times s$$

where G = B.t.u. per min. equal to 1 gal. deg.
s = specific heat of brine
g = specific gravity of brine
8.35 = weight of 1 gal. of water

Gallon degrees per ton of refrigeration is calculated as follows: We know that 288,000 B.t.u. must be extracted in 24 hr. to produce one ton of refrigeration, then for 1 hr. this equals 288,000 ÷ 24 = 12,000 B.t.u. and for 1 min. this equals 12,000 ÷ 60 = 200 B.t.u. which must be extracted per unit of time to equal 1 t. of refrigeration.

Now the gallon degrees equal to 1 t. of refrigeration is found by dividing 200 by the B.t.u. in one gallon degree or

$$D = \frac{200}{G}$$

where D = gallon of brine per ton of refrigeration

After the gallon degrees per ton is found, it is only necessary to find the discharge and return temperatures of the brine, and the number of gallons circulated per minute to ascertain the refrigeration capacity of the system which is as follows:

$$R = \frac{V \times (t_1 - t_2)}{D}$$

where R = Capacity in 24 hr.
V = Brine circulated in gal. per min.
t_1 = Return temperature of brine
t_2 = Discharge temperature of brine

The refrigeration capacity of the system is thus seen to be a comparatively simple matter.

Chicago, Ill. GILBERT R. WRAY.

Crankpin Box Adjustment

MARINE TYPE crankpin boxes, as used on stationary engines, Fig. 1, are adjusted by varying the thickness of liners clamped between the box ends. Liners of varying thinness are used to give close variation so that pound will be avoided yet leave a safe running clearance. One method is to change liners until the boxes just hug the pin when nuts are drawn up tight; then slack off the hexagon nuts one face, or 1/6 turn. This gives clearance 1/6 the pitch of the thread which may or may not be right. Screwing up the jam nuts is likely to increase the slack so that a slight pound will result, the bolts will be subjected to rapidly repeated shock and may eventually crystallize and break.

Flattening soft lead wire between box and crankpin and calipering this wire with a micrometer is one way to get exact clearance. Another is to set inside micrometer calipers to the pin diameter plus the desired clearance and adjust the liners until the boxes caliper correctly, the pin being removed while making the adjustment. In either case, clearance needed is about 2/1000 in. per 1 in. pin diameter for pins up to 2.5 in.; about 15/10000 in. per 1 in. diameter for larger pins. Running without pound or heating is the test of correct adjustment.

For locomotive rods, boxes are fitted without liners, the ends being filed down to adjust for wear. Evidently, this calls for care that clearance be exact.

In these, Fig. 2, the screw set is slacked off, the key driven in until brasses hug the pin, then driven back slightly to get clearance. If taper of the key is 1/32 in. per inch of length, driving back 1/16 in. will give clearance of 1/512 in. or about 2/1000 in. In any case, the clearance will be taper per inch of key length times the distance the key is driven back. One test is to drive back until the boxes can just be moved endwise on the pin by hand. Tightening the set screw will hold the key in position.

For two bolts, Fig. 3, slacking off on the bolt A and tightening up B will take up wear. Generally drawing

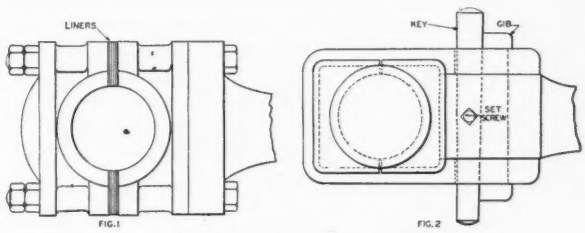


FIG. 1. MARINE TYPE BOX WITH LINERS
FIG. 2. GIB AND KEY ADJUSTMENT

up on B until the boxes are snug, then slacking off "one flat," or 1/6 turn and tightening A, will give enough clearance, but running should be watched, as the amount of clearance so given depends on taper of the wedge and pitch of the bolt threads, so may be inadequate, if taper is slight and threads of fine pitch.

If bolts happen to draw the wedge away from the rod end at C, a strain is put on the bolts which may cause breakage. This can be avoided by making the holes for the bolts in the rod end sufficiently oblong so

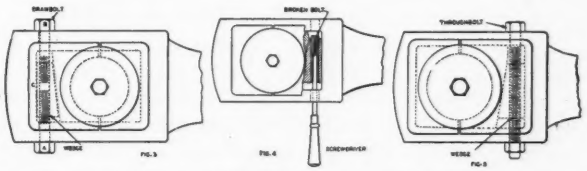


FIG. 3. DRAW WEDGE WITH 2 BOLTS
FIG. 4. SLOTTED BOLT END FOR EASY REMOVAL
FIG. 5. SINGLE BOLT DRAW WEDGE

that the wedge will be sure to seat at C. While a broken bolt end can be removed by drilling a hole and driving in a square reamer to serve as a wrench, it will save time and possible injury to threads in the wedge, if the ends of bolts are slotted so that, in case of breakage, they may be removed with a screwdriver, Fig. 4.

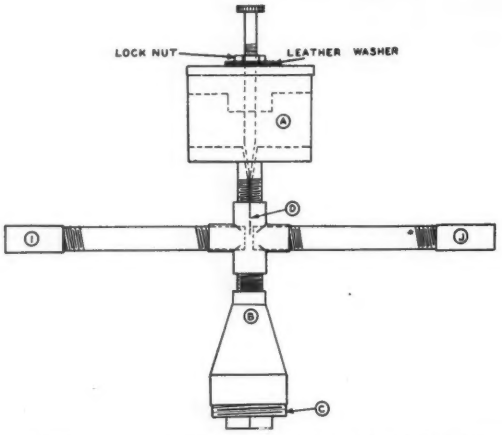
While the single bolt, Fig. 5, is more easily adjusted than the two-bolt arrangement and can be more easily removed in case of a break, it gives no means of locking the wedge, which may have some play unless the fit between bolt and wedge threads is exact.

In any case, bolts of high grade wrought iron are likely to resist such shock as they may meet better than will bolts of machine steel. If the bolts break repeatedly just beneath the head, countersinking the holes slightly and using bolts with a filet under the head, of size to fit the countersink may cure the trouble.

St. Louis, Mo. D. J. ALTIZER.

Combination Lubricator and Moisture Trap

INEXPENSIVE construction of a lubricator with separator features may be made in a few minutes at a cost of not over $1.50 as shown in the sketch in which A is a small screw-top oil cup with a threaded spindle to control the feed. All connections, except the ¾-in. plug, C, at the end of the coupling, B, are ¼-in.



LUBRICATOR AND MOISTURE TRAP MADE OF FITTINGS

A small amount of oil is allowed to run down the wire, D, the air pressure then breaks up the oil into a spray in the space between the ends of the nipples. If any moisture is present in the air supply it will tend to run along the sides of the fitting and collect in the separator, B, and is removed by unscrewing plug, C.

Toronto, Canada. JAMES E. NOBLE.

Voltage Regulator Trouble Cured

ONE OF MY FRIENDS took charge of a small plant where 125-v. d.c. shunt-wound generators supplied power for various motors and heating devices for process work. The previous operating engineer had been an ingenious chap. One of his achievements was a small voltage regulator which really did smooth out the voltage drops and peaks due to load changes in process work. One of the characteristics of its operation was to cause a tendency for the lights to flicker at certain loads. This the new engineer wanted to stop and as the writer had had some experience with this type of control, he was called upon for advice and suggestions.

As this type of regulator is sensitive, it is easily built and will control nicely the resistance of the shunt field. The circuit is given below. The control is entirely automatic and the regular field rheostat that usually is provided with such machines can be used as a resistance base. Cost of building the control was $65 in 1929.

Self-induction of the solenoids was found to be the factor that kept the armatures working when they should be quiet. It will be seen from the circuit that the inductive kick of the two coils was transmitted back and forth as the circuits were broken by each other and this effect had to be stopped. The amount of this kick was not a factor that was objectionable otherwise, therefore the writer suggested a dashpot consisting of a tin can containing oil of the proper body in which worked a loosely fitting piston, the piston being a brass disc soldered to the end of a fairly heavy piece of copper wire.

The dashpot was 3½ in. in diameter and was filled two-thirds full of medium motor oil. As the stroke of the master armature was only about 0.03 in., to secure damping of sufficient intensity the master armature was lengthened to 15 in. total radius so that the stroke at the contacts of 0.03 in. was multiplied to about 0.20 in. for the dashpot piston. This damping effect was sufficient to overcome the inductive kick of the coils and after the device was again put in service the continued flickering of the lights stopped and the device worked better than ever. The additional weight of the extended lever was taken care of by added spring tension.

The solenoids were standard three-pound-pull capacity alternating-current plunger type devices with the plungers about ⅜ in. from being sealed to avoid sticking. Both coils were wound for 110 v., 60 cycles temporary

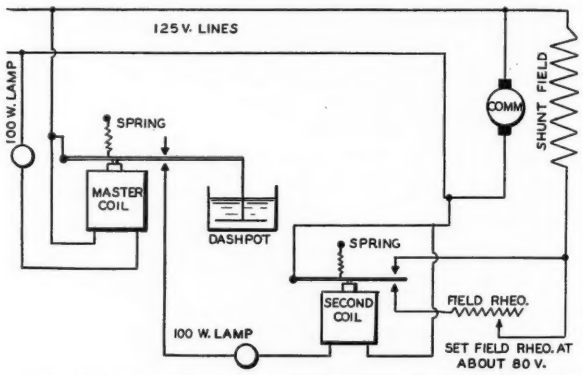


DIAGRAM OF VOLTAGE REGULATOR CONNECTIONS

rating, therefore 100-w. lamps were placed in series with them so they would be good for continuous duty. The levers or armatures were of flat brass ½ in. wide and the contacts were simply brass screws filed off flat. As contacts breaking about 10 amp. these would probably not be highly esteemed but they were cheaper to renew every three months than to buy regular tipped contacts. Carbon contacts would be better. Once a week a doubled piece of fine sandpaper was passed between the contacts and their armatures to keep them fairly clean.

Hanover, Pa. JOHN S. CARPENTER.

Soldering Iron for Small Work

MANY TIMES, soldering work that requires a small soldering iron has to be done. Such an iron does not hold sufficient heat to enable one to accomplish much before the iron becomes too cool to melt the solder.

SMALL POINT SOLDERING IRON THAT RETAINS HEAT

The writer has on several occasions taken a large or medium size iron and reduced the point to make a small point projecting from the body of the larger one and the difficulty is overcome, the larger iron holding the heat to be released through the small point to do the work.

Cambridge, Mass. M. W. EASTMAN.

Questions
How does a centrifugal shaft governor differ from a governor using both centrifugal and centripetal force?
and Answers

Boiler Feed Pump Sizes

WE WOULD LIKE to know whether a 4½ by 2¾ by 4-in. boiler feed pump is large enough to use with a 250 -hp., 125-lb., Stirling boiler. W. C. W.

A. Based on 34.5 lb. evaporation, pumps of this size at a normal speed of 22 f.p.m. or 33 r.p.m. are rated by the manufacturer at 180 b-hp. This rating should not be exceeded for continuous service. Sizes and capacities of a number of boiler feed pumps of the horizontal duplex packed piston type is given in the following tabulation.

NORMAL CAPACITY OF PACKED PISTON HORIZONTAL DUPLEX BOILER FEED PUMPS FOR CONTINUOUS SERVICE

Diameter of Steam Cylinders, In.	Diameter of Liquid Pistons, In.	Length of Stroke, In.	Gal. Per Min.	Hp. Boilers Pump Will Feed	Piston Speed Feet Per Min.	Revolutions Per Min.
3	2	3	6	80	18	36
3½	2¼	4	9	120	22	33
4½	2¾	4	14	180	22	33
5¼	3½	5	24	325	24	29
6	4	6	34	460	26	26
7½	5	6	53	725	26	26
7½	4½	10	63	845	38	23
9	5¼	10	86	1170	38	23
10	6	10	112	1515	38	23

For fuel oil service, the pump should operate at about the same speed as for boiler feed service, but for general service it can be speeded up about 50 per cent. For emergency boiler feed service, the capacity can be increased about 30 per cent over that given in the table.

Air Required for Combustion

HOW DO YOU figure the cubic feet of air needed for the combustion of a cubic foot of gas? C. T. M.

A. Complete information regarding calculations for natural gas combustion problems will be found in the series of articles by Palmer B. Place. The one dealing with air supply appeared on page 545 of the May 15, 1931 issue.

The approximate amount of air can be figured in the following manner if the gas analysis is available. Natural gas ordinarily contains some combination of the constituents shown in the first column of the tabulation.

Carbon dioxide	CO_2	....
Carbon monoxide	CO	2.38
Hydrogen	H_2	2.38
Methane	CH_4	9.52
Ethane	C_2H_4	14.3
Ethylene	C_2H_6	16.7
Nitrogen	N_2	....

Figures in the second column show the cubic feet of air theoretically required for the combustion of 1 cu.ft. of that particular gas. That is, a cubic foot of hydrogen will require 2.38 cu. ft. of air.

For instance, a gas which is 84 per cent CH_4 and 8 per cent C_2H_4 would require 0.84×9.52 or about 8 cu. ft. of air for the CH_4 and 0.08×14.3, or about 1.14 cu. ft. of air for the C_2H_4 giving a total requirement of 9.14 cu. ft. of air per cubic foot of gas. In this particular gas the balance, or 8 per cent, was made up of CO_2 and N_2 both inert, and as such require no oxygen for combustion.

The amount of air actually supplied would depend upon the excess air desired. The CO_2 content with most natural gases will run from about 11.5 per cent with zero excess air down to about 7.5, with 50 per cent excess air, but this is subject to considerable variation because of the variations in gases from different fields.

Reboring Cylinders

WE PLAN to rebore the cylinder of an 18 by 36 by 42-in. Hamilton Corliss cross compound engine and would like to know what clearance we should allow for the new bull ring and for the packing rings. R. E. B.

A. New bull rings should be made 0.001 per in. of diameter plus 0.005 in. smaller than the diameter of the cylinder and packing rings should be finished to exactly the diameter of the cylinder, according to R. S. Henninger, manager of the repair department of the Hooven, Owens, Rentschler Co. In this case, the high-pressure bull ring should be made 0.023 in. smaller than the diameter of the cylinder and the low pressure bull ring should be made 0.041 in. smaller than the diameter of the low-pressure cylinder.

Reboring cylinders, especially of an engine as large as this should, if possible, be done under the supervision of an expert engine man. Portable tools which can be shipped inexpensively to all parts of the country are available and in this way a first class job requiring the minimum outage is assured. It also saves the time and expense of rigging up a temporary boring bar and equipment around the plant.

Boiler Calculation

In the formula given in the second column, page 627 of the June 1, 1931 issue, the quantity R is equal to the radius in inches to which the head is dished, unless the radius is less than 80 per cent of the diameter of the drum in which case R is taken as 80 per cent of the diameter of the drum.

DRIPS OR DRIP POCKETS should be placed wherever a water pocket might form in a steam line.

Editorial Comment

The Power Plant of the Future

It has been predicted that the best probable performance that may be expected from a steam turbine is about 9500 B.t.u. per net kilowatt-hour, with steam at 2500 lb. pressure, 1000 deg. total temperature, using two stages of reheating to the initial temperature and six stages of bleeder heating. Whether the mercury vapor cycle can lower this performance figure remains to be seen. Moreover, the full possibilities of various cycles employing diphenyl, diphenyl-oxide and zinc ammoniate have not yet been determined.

All the foregoing methods of power development, however, possess in common the necessity for burning fuel to generate heat. It is this combustion problem that gives power plant engineers the most concern and if a new and better solution could be found for that, it would repay all the trouble of finding it.

An indication of the possibilities of further research in the obtaining of atomic energy directly in the form of radiation has recently been given by Leo G. Hall in Mechanical Engineering.

The radiation might be of the same type as the cosmic rays that readers of Power Plant Engineering have learned about in Mr. Kramer's recent articles on Electricity—What It Is and How It Acts. Scientists possess much direct evidence that these rays are produced, at the extremely low temperature of interstellar space, by the synthesis of complex atoms from simple ones, the conversion of hydrogen, for instance, into helium.

Mr. Hall suggests that hydrogen, of which there is an abundant supply, might be subjected in a suitable enclosure to temperatures but little above absolute zero. The technique of producing these low temperatures is even now available. At such temperatures, transformation of hydrogen into a more stable element might occur, as it does in interstellar space, in which process the small loss of mass would be accounted for in radiation of the order of the cosmic rays.

Inasmuch as these rays will penetrate many feet of lead, the conversion would probably have to be made in a chamber with walls of lead 40 or 50 ft. thick, in which conduits carrying water or other circulating fluid might be placed to absorb the radiation.

Although the lowest temperature we can now produce—within less than a degree of absolute zero—might not be low enough to transform the hydrogen into a more stable element, such as helium, further research might refine the process to the point at which the equilibrium of the hydrogen would be destroyed. Or possibly at the lowest temperature we could attain, radiation with X-rays or gamma rays or bombardment with protons or alpha particles might be sufficient to push the electron arrangement over the edge of equilibrium.

Recently an X-ray tube of 900,000 v. working potential was developed. If a tube operating at 8,000,000 v. could be constructed, we could impart velocities to alpha particles of the same order as those which are obtained naturally in radioactive disintegration.

The supply of hydrogen is so great that even though less than one per cent of its mass could be converted by synthesis into radiation, says Mr. Hall, with an efficiency of operation only one-tenth that of our present power plants, the danger of a power famine would be moved several million years into the future.

From the atomic energy standpoint of course, the efficiency of the average present day steam power plant has been calculated to be only about 0.000,000,001,2 per cent. We assume, however, that Mr. Hall is speaking of thermal efficiency of the order of 10 or 20 per cent as we ordinarily measure it.

Here at least is something to think about. We can't carry out the above synthesis with our present methods but we do not know what further research along this line might bring forth. If we can judge by scientific history, however, whatever the power plant of the future proves to be, new methods are just ahead. The power engineer will be safer, if he regards his present methods as a point near the lower end of a long upward curve of development. Then he will not be surprised at anything that happens.

Special Heat Resisting Alloys

Great strides have been made in the development of special alloys with heat, corrosion and acid-resisting properties and it has been found that most of these alloys are serviceable only under the conditions for which they were developed. Manufacturers have found that castings and pipe, supplied particularly for industrial purposes are often, through carelessness or ignorance, subjected to conditions of fuel, atmosphere and temperature not set forth in the original specifications, resulting in failure of castings and alloys which were not made for these conditions.

The limited range of these special alloys has been recognized by the Heat Corrosion Resisting Alloy division of the Steel Founders Society, and incorporated with the standard form of contract, limiting the period of liability in industrial furnaces to 90 days from date of first operation and this only when the conditions of fuel, atmosphere and temperature as set forth in the specification, come within the maximum variation of operation.

Special alloys of this kind are becoming of importance in the power plant field. Their field of usefulness is gradually widening and, if failure and disappointments are to be avoided, the power plant industry could well take a leaf from the costly book of experience of the industrial field and determine with considerable accuracy the conditions to which these special alloys are to be subjected before specifying definite compositions.

Prevention of Noise

Noise and its effects on human beings have never been studied qualitatively until comparatively recent years. It has always been known, of course, that those effects were not good, but as long as there were only intermittent noises of various intensities there was little complaint.

In our machine civilization the problem of noise, however, has rapidly assumed major proportions. Nowadays in a big city we are affected by the entire range of noises all at once. The investigations of city noise made by the Noise Abatement Commission of New York City have proved of inestimable value. One table prepared by this commission showed the following classification of complaints from citizens as to the sources of city noise: traffic (trucks, horns, cut-outs, brakes, buses, traffic whistlers) 36.28 per cent; transportation, such as elevated, street and subway cars, 16.29 per cent; radios, 12.34 per cent; collections and deliveries, such as of ash, garbage, milk, ice, 9.25 per cent; whistles and bells, 8.28 per cent; construction, using riveting and pneumatic drills, 7.40 per cent; vocal, such as newsboys, peddlers, dogs, cats, noisy parties, 7.27; others 2.89 per cent.

Just what can be done to stop these noises remains to be seen. We know now that the continual impact of city noises on the ear nerves of human beings dulls the hearing, produces a condition of continual nerve strain, destroys efficiency, produces neurasthenic and psychasthenic states in many individuals, interferes with sleep and affects the development of children. Clearly the remedy for these conditions lies not in the hands of politicians, who may be deterred by fear from attacking the evils at their source, but rather in the hands of physicians, engineers and scientists, reënforced by an enlightened public opinion.

It is important to note that already the engineering profession has done a great deal of work in the abatement of noises in places where machinery operates. Without doubt much of this work can be adapted to the prevention of the city noises mentioned above.

Consider, for example, this list of papers recently presented at the Northeastern District Meeting of the A.I.E.E.—Noise Mitigation in Substations, Measurement of Noise in Electrical Machinery, Elastic Supports for Isolating Rotating Machinery, Magnetic Noise in Synchronous Machines, Measurement of Machinery Noise, Indicating Meter for Measurement and Analysis of Noise. This list is typical of the sort of work engineers have been doing for some time in this important field.

Of the various applications of noise preventing principles, the outstanding example is the new windowless plant of Simonds Saw and Steel Co. Here, we understand, sources of noise will be eliminated so far as possible and it is expected that the factory will be quiet enough so that desks of foremen and superintendents can be placed right among the machines and that telephoning and conversations in an ordinary tone of voice can be carried on as well as in an office.

On the whole, industry is far in the lead in preventing noise. For one thing industrial noise in most cases means actual physical friction; in other words, waste of power. Again, industrial noises are not so intense, on the whole, but are more sustained and less likely to produce nerve shocks. Certain machinery noises, such as the characteristic "click-plop" of a Corliss valve gear or the musical drone of a steam turbine, actually assist in operating the machine. There still remain many factory noises that have bad effects on workmen but they are gradually being eliminated.

In short, the engineering technique for the elimination of all sorts of noise is already well developed. When the general public demands relief from noise, the engineer and the physician stand ready to suggest remedies. It will then devolve upon the public to accept or rejcet them.

Competition

Successful operation of a power plant demands the coöperation and coördination of all departments and in addition a spirit of friendly competition. Up to a certain point, efficiency depends upon the machine but beyond this the last few per cent which are so hard to get depend upon the operator. The measure of the chief engineer's ability is the extent to which he has his crew organized to get these last few per cent.

In central station organizations, competition between different stations in a system can be promoted to keep operators interested. Difference in operating conditions and equipment can be evened out by establishing base performance or bogey curves for the particular station, measuring operating performance above or below this line. This scheme can also be used to advantage in industrial plants by establishing bogey curves for the different departments and measuring their relative performance as a plus or minus percentage. In making these curves, it is essential to keep in mind the plant as a whole and not subordinate it to some one part of the plant.

Another form of competition which can be used for inter-department competition is housekeeping and safety. The former pays handsome dividends in increased morale of the staff and the second in actual cash by the reduction of lost time, hospital bills and liability compensation.

Accident Costs

Costs of accidents are not easy to determine accurately except in a few organizations as there is only the loss to the industry, the doctor's bill, decreased production and interrupted schedule, but there is a direct loss to the worker himself, sometimes a result of his own carelessness but quite often due to the carelessness of others.

As these costs are often hidden, they are not always appreciated by the operator or worker and to impress the cost of liability insurance, the cost of which is definitely known to the employers, one ice man made the following comparison, using 50-lb. cakes of ice as a unit of measurement.

For every working day in the year, it takes 2000 of these 50-lb pieces to pay the liability insurance bill of that organization. Some accidents, are, of course, unpreventable but it is the preventable accidents that run the cost of insurance up and forms one of the known and large economic wastes in all industries.

The Fifty-Fourth N. E. L. A. Convention Atlantic City, N. J.

FOR THE SECOND TIME, the annual convention of the National Electric Light Association was held in the new Convention Hall at Atlantic City, N. J. Two years ago, in 1929, it may be recalled, this magnificent auditorium which has an exhibit area of 268,000 sq. ft. and which seats 40,000 persons was dedicated just prior to the 52nd N. E. L. A. convention. And, now, from June 8 to 12, it was the scene of the 54th N. E. L. A. convention.

That this Fifty-fourth convention in the history of the Association just past was a great success will not be questioned by anybody so fortunate as to have had the privilege of attending. For it is a privilege to attend this annual gathering and if one came away with nothing more than this inspiration which seeing this great co-operative organization in action brings, it would be well worth while. But it offers much more than mere inspiration; it offers information, knowledge and understanding needed by the men and women in the electric light and power industry. And this year particularly, when it is so vitally necessary to economize and to give value for money expended, the speakers and subjects were selected with care in order that the meeting might have a maximum value to those attending.

In a world permeated with gloom and with the devastating consequences of a world wide economic depression visible everywhere, the N. E. L. A. convention was a welcome oasis of optimism and confidence in a more hopeful future. The electric light and power business, it is true, has suffered loss of business, but not nearly as much as have other lines of industry. As W. Alton Jones, president of the Association pointed out in his opening address, "the industry stood out in striking contrast to almost every other line of business."

Comparing the reports of more than 600 corporations for the first three months of 1930 and 1931, Mr. Jones pointed out that while earnings of 259 industrial corporations, taken as a whole were 54.8 per cent under those of the previous year and 171 railroads showed a decrease of 39.3 per cent, 76 light and power and gas companies showed a decrease of only 1.6 per cent. "If this comparison is to be taken as a measure of the relative effect of the business depression on industry" he said, "it will be seen that the electric power industry has been greatly favored. This it seems is rather conclusive evidence as to its diversity and stability."

Convention is Officially Opened on Tuesday

Although the convention began on Monday, June 8, it was not officially opened until Tuesday morning, when a welcome was extended by the Hon. Harry Bacharach, the mayor of Atlantic City. Following the mayor's address in which he expressed his belief against municipal ownership, President W. Alton Jones delivered his opening message. Under Mr. Jones' able guidance, the Association has weathered a stormy year successfully. This, however, might have been expected for this young executive—he is only 40—has had phenomenal success in his career. Not only is he first vice president of the Cities Service Co. and chairman of the executive committee of Henry L. Doherty and Co., but he is an officer and/or director of more than 100 other companies.

Mr. Jones in his address was particularly bitter in regard to the contemptible stratagems of the demagogues and the cheap political expediency behind the many attacks upon the public utilities. At the present time, he said, he was not so much concerned with the actual legislation which these attacks might bring about but with the effect which all this bitter and baseless agitation may have upon the thinking investors and customers of the utilities. By reckless and irresponsible charges these politicians are seeking to stir up a war

of words, hoping to obscure all other issues until after the next election.

As to the charges of the demagogues, Mr. Jones ridiculed the contention that the bill of less than 10 cents a day for the average American home is exhorbitant and that it amounts to extortion. "I firmly believe," said Mr. Jones "that the predatory politician who makes such contentions is insulting the intelligence of the average American citizen. I believe the average citizen is intelligent enough to see the difference between the low cost of electricity and the high cost of politics. It is no longer a secret that the cost of our political institutions has become one of the greatest burdens our people have to bear. The tax gatherers of this country are now taking a toll of over $12,000,000,000 a year from the pockets of the people of this country. This represents more than 20 times as much as the domestic customers now pay for electric service."

The electric light and power industry alone pays in direct taxes approximately $200,000,000 a year which represents 10 cents out of every dollar collected in gross revenues and almost a third of all money collected for domestic electricity.

Following Mr. Jones' address and the presentation of the treasurer's report, the meeting was privileged to hear Paul S. Clapp, managing director of the N. E. L. A. Mr. Clapp's address although brief gave ample evidence of the many activities carried out by the association and of its remarkable growth. From a membership of 200 in 1900 to 21,563 in 1931, the N. E. L. A. has developed into an organization of unrealized usefulness and scope of interests. Touching upon the high points of the annual report regarding the association's activities, Mr. Clapp paid tribute to the influence of the N. E. L. A. upon employee training and education, safety engineering, public relations, commercial and rural development and many other lines of progress. Seventy per cent of American homes now enjoy the benefits of electric service. In 1930, some 100,000 farm customers were added to the lines of the public service companies. There are now more than 300,000 employees directly engaged in the light and power business. Mr. Clapp further pointed out that the kilowatt hour consumption in domestic use increased 8.5 per cent in the first third of 1931 over 1930 and over 24.5 per cent over the same period of 1929.

Among the other interesting speakers at the first general session were David Lawrence, publisher of the United States Daily at Washington, D. C., and Gus W. Dyer, editor of the Southern Agriculturist of Nashville, Tenn. Mr. Lawrence presented a "long look ahead in business." As a trained observer of the general trend of world events, Mr. Lawrence is well qualified to speak on this subject, and his remarks contained many excellent suggestions. The sick industries, he said, are all suffering from the common ailment of having to acquire new markets. There must be developed a scientific improvement in the great system of interchange if the world is soon to emerge from the slough of stagnation. This, he said, must inevitably include readjustment of tariff barriers.

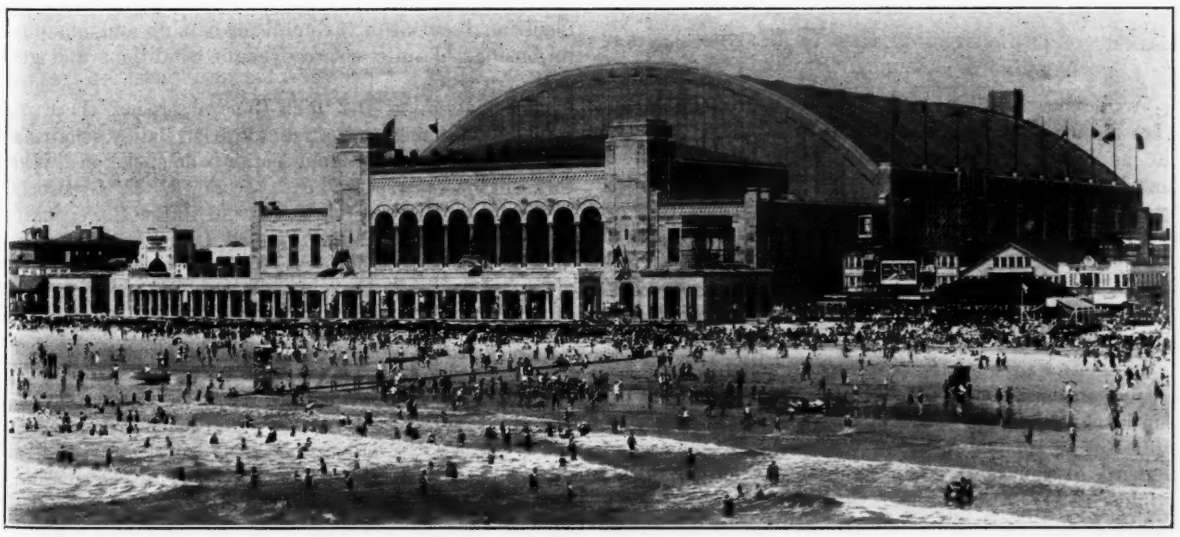
Gus Dyer, editor of the Southern Agriculturalist advocated making friends with rural dwellers as the pass key to sound politics. He pointed out that electricity in bringing about the decentralization of industry by the establishment of manufacturing plants in places remote from the cities, has brought us face to face with the second great industrial revolution. The first industrial revolution occurred something like 150 years ago, by the simple application of steam to machinery. Now, electricity in providing remote communities with cheap electric power, he said, will bring about the second industrial revolution.

Both of these talks were among the important events of the day and held particular interest because they reflected views of men outside the industry.

The morning session was concluded with a most interesting demonstration entitled "Energy Through Space," given through the courtesy of the General Electric Co. This included a number of laboratory experiments depicting the marvels of science.

Engineering Sections Scan Cost Savings

A decidedly healthy sign was evident at the session of the engineering section held Tuesday afternoon. It involved an introspective attitude, the presentation of



outside viewpoint and the first specific tangible answer to "why the spread between production costs and selling price." Chairman Alex D. Bailey referred to the feeling encountered in some quarters that the industry has developed to a high state of perfection and that there is not much more which the engineers can do to reduce costs. He indicated, however, that there is an inconceivable number of units involved and that each of these small increments amount to a tremendous sum in the aggregate. Also, he said the industry is on the threshold of tremendous technical developments.

George N. Tidd, president of the American Gas and Electric Company, called attention to an economic waste caused by accidents. He presented eight suggestions for executives improving the situation, chief among which were bringing pressure to bear on reduction of accidents and fixing responsibility, establishing specifications on clearances and safeguards and promotion of safety consciousness.

The outside viewpoint at the Technical session was presented by Harvey N. Davis, president of Stevens Institute, who tried to assume the rabid propagandist attitude toward air pollution but who injected that sober, rational viewpoint that is most helpful in solving any problem. Dr. Davis divided agitation in favor of smoke abatement into four classes with the following motives: (1) fuel economy, (2) avoidance of property damage, (3) preservation of public health and (4) removing of depressing psychological conditions.

Metropolitan Distribution Costs

A classic was presented by A. C. Marshall and H. A. Snow on a subject that has been the victim of greater misinformation than probably any other distribution cost. Based on a specific metropolitan distribution system, they broke down the total distribution costs for domestic customers and showed specifically the detailed functions for which the consumer's dollar is expended. They also showed how this total expense changes with kw-hr. usage per year—about 10 cents for 200 kw-hr., 5.28 cents for 500 kw-hr., 2.23 cents for 3000 kw-hr.

Nominations for the coming year included A. H. Kehoe as chairman of the engineering section, M. Eldredge, vice chairman.

Main Issue of Convention that of Defense Against Attacks of Political Demagogues

While nearly all phases of public utility operation were discussed at the various sessions during the week, the main issue which dominated was that of resentment and defence against the vicious attacks on the industry by unscrupulous politicians. At nearly every session, this problem of how to counteract these attacks came in for discussion and many able leaders both within and without the industry expressed their views in no uncertain terms. The opinions of W. Alton Jones already have been referred to.

Both J. F. Owens, first vice president of the Association and W. C. Mullendore, vice president of the Southern California Edison Co., presented vigorous addresses on this subject. On Wednesday at the second General session, and again Thursday evening at the Public Policy session, Mr. Mullendore in masterly addresses answered the untruthful attacks on the industry. He did not claim that the industry was perfect and welcomed fair criticisms, but he did object most strenuously to the unfounded statements which have been made to stir the emotions of hate, fear and envy; break down confidence in legitimate ethical business conduct and displace the basic principles of this country.

As usual public relations was an important subject and among the speakers who presented their views on this subject at the Public Relations Section session on Thursday were Harry Reid, chairman of the section, Homer Ferguson, president of the Newport News Shipbuilding and Drydock Co., Homer Niesz, chairman of the industrial relations committee, Miss Clara Zillessen, chairman of the women's committee and Martin Insull, president of the Middle West Utilities Co.

Public relations may be regarded as the barometer of public acceptance of service in the opinion of H. P. Liversidge. Speaking on this subject before the Commercial Section he pointed out that a large part of public relations was within the control of the industry through its contacts with its customers. In his opinion, the industry's chief difficulty comes from the public's disbelief that it is protected from the utilities in their form of monopoly and the further belief that the industry is in command of a mysterious force of Nature. In the opinion of Mr. Liversidge the salesman can do much to correct these mistaken notions.

Harry Reid in discussing this same subject urged the translation of technical language into the language which the customers can understand. It is not enough he said, to publish an advertisement stating that electricity is cheap because the average household rate has been reduced 31 per cent between 1913 and 1930 and now stands at 5.95 cents per kilowatt hour. It should be translated into terms of the customer's own experience, that is, in terms of a stick of gum, a package of cigarettes or an ice cream soda.

Perhaps the principal event on the Thursday night public policy program was the presentation of the Charles A. Coffin award to the Virginia Electric and Power Co. This award is made annually to the company which has made a distinguished contribution to the development of electric light and power for the convenience of the public and the benefit of the industry. The winning company was credited with 95 points out of a possible 100. It made progress in the face of a traditional sentiment for public ownership and expanded its business despite severe drought conditions and general depression.

At this session, the third General session, there was four notable speakers; first Alex D. Bailey, chairman of the engineering national section who spoke on "What the Engineers Are Doing;" second, C. E. Groesback, president of the Electric Bond and Share Co. speaking on "Brakes on Prosperity;" third, Gerard Swope, president of the General Electric Co. on the subject of coöperation between industry and the employees and fourth, Merle Thorpe, editor of the Nation's Business, whose subject was "Our Vanishing Economic Freedom."

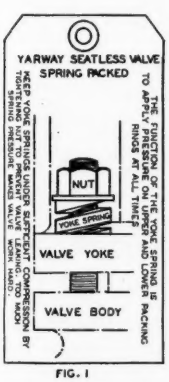
The final session included the presentation of Rewards of Merit, by Frank W. Smith, chairman of the Prize Awards Committee and the reading of Memorials by W. H. Onken, as well as the report of the nominating committee and the introduction of the president elect J. F. Owens, president of the Oklahoma Gas and Electric Co.

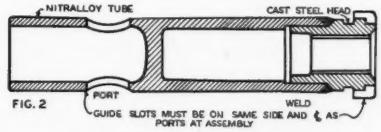
Power Plant Engineering Developments and News

Improvements on Blowoff Valves

SEVERAL IMPROVEMENTS on various types of blowoff valves as shown herewith have recently been made by Yarnall-Waring Co. of Philadelphia, Pa.

On the balanced seatless blowoff valve to make adjustment of the packing as near automatic as possible, springs have been added under the yoke nut as shown in Fig. 1. The function of these yoke springs is to apply pressure on the upper and lower packing rings of the valve continuously in order to relieve the operating staff from the responsibility of frequent adjustment of the yoke nut which has been necessary in the past. When using these springs, the yoke nut should be adjusted so that the springs are under sufficient pressure to prevent the valve from leaking. The operating staff is cautioned not to apply too much spring pressure as this will make


YARWAY SEATLESS VALVE
SPRING PACKED
KEEP YOKE SPRINGS UNDER SUFFICIENT COMPRESSION BY TOTAL SPRING PRESSURE MAKES VALVE WORK HARD
THE FUNCTION OF THE YOKE SPRING IS TO APPLY PRESSURE ON THE UPPER AND LOWER PACKING RINGS AT ALL TIMES
NUT
YOKE SPRING
VALVE YOKE
VALVE BODY
FIG. 1



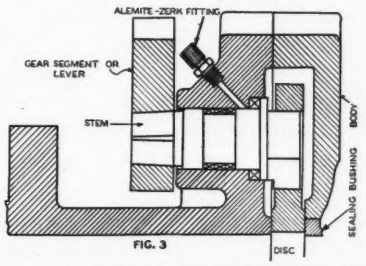


FIG. 1. SPRINGS UNDER YOKE NUTS ELIMINATE FREQUENT ADJUSTMENT
FIG. 2. NITRALLOY PLUNGER TO DECREASE WEAR
FIG. 3. GREASE FITTING FOR VALVE-STEM LUBRICATION

the valve work hard. Pressure adjustment can easily be determined by the ease of turning the hand wheel.

A second improvement on the seatless valve has been the development of the nitralloy plunger, Fig. 2. For many years cast plungers were used but owing to occasional porosity and resultant leakage, it was found desirable to use forgings. Recently nitralloy has been adopted for the tube; this is welded to a cast-steel head in which the stem of the valve operates. The nitralloy tube is machined on a solid nitralloy bar and after machining, including polishing of the outside diameter of the tube, the tube is nitrided, the head is assembled and welding completed. A process of welding has been developed by the manufacturer for welding the nitrided tube to the cast-steel head. This construction, it is stated, increases the life of the plunger since the surface is so hard that grit and scale matter in the blowdown do not easily erode it.

On the Yarway double-tightening valve, the new feature shown in detail in Fig. 3 consists in an Alemite fitting through which grease is forced under pressure to the stem of the valve between the stem packing. The manufacturer has found that this not only makes the valve operate much more easily but also increases the life of the packing. For these double tightening valves a new adjustable stem packing gland has also been developed, made in the 2½-in. size only. In this case also, the Alemite fitting is used and the grease is forced to the stem.

Ready-Mixed Concrete Plants

MIXING OF CONCRETE by the batch proportioning method has been widely adopted and to perform this mixing automatically, rapidly and precisely, Stephens-Adamson Mfg. Co. of Aurora, Ill., has recently developed a new type of concrete mixing plant as shown in the illustration.

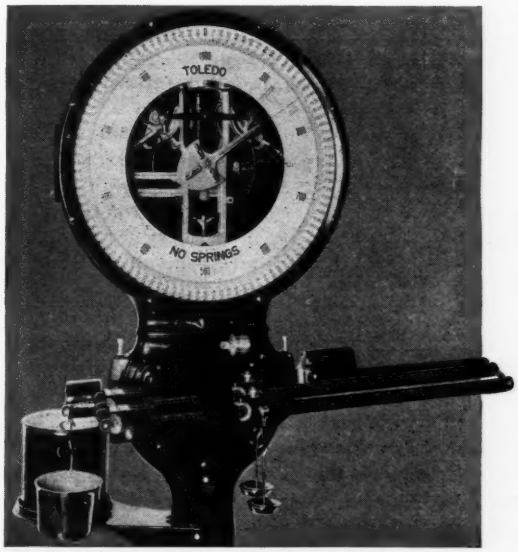


FIG. 1. AUTOMATIC DIAL SCALE

In the batch proportioning method, the measurement of cement, sand, aggregate and water by weight forms the fundamental principle. The equipment consists of suitable hoppers for aggregate, weighing hoppers for cement, water and aggregate and specially designed

Toledo springless scales for performing the weighing operations. On these scales, electric photo-cells, (commonly known as the electric-eye) are set at a predetermined weight on the dial and when the prescribed amount of material has been weighed, the photo-cell closes a relay switch that shuts off the supply.

In the batch proportioning method, it is necessary, of course, to make a determination of the moisture in the aggregate so that the correct amount of water can be added to the mix. The Toledo scales are especially designed to make this determination.

Two dial scales are used, one for weighing the fine and coarse aggregate and the other for weighing the cement and water for the batch. All controls for the equipment are gathered in a control box from which by manipulation of a push-button, the operator controls the entire procedure. This is performed as follows:

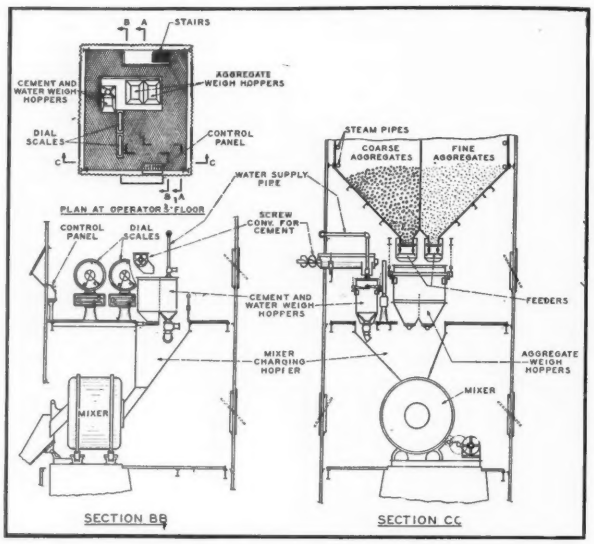


FIG. 2. CROSS-SECTION SHOWING LOCATION AND OPERATION OF MIXING EQUIPMENT

First, the moisture content determination device is used to ascertain the percentage of surface moisture present in the fine aggregate. Second, knowing the amount of surface dry sand required for the mix, it is simple to compute the batch requirements with proper compensation for the moisture content, which has just been determined. The operator then pushes the button for the fine aggregate feeder delivering into one hopper and the push button starting the cement conveyor delivering to the second weigh hopper. As soon as these two ingredients have been drawn into the weigh hoppers, the pilot lights will flash to indicate completion. The operator then shifts the poises of the scales into the proper position and engages the push-button starters for the other two materials, coarse aggregate and water.

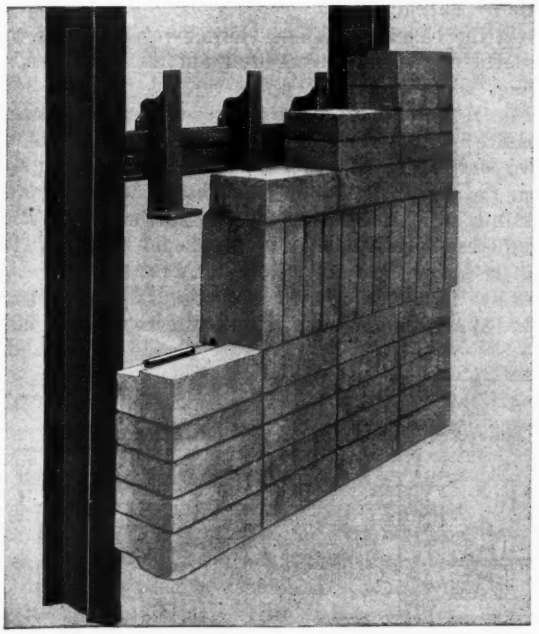
When all the hoppers have been filled with the correct amount of material, the operator is ready to discharge the batch. This may be discharged directly into the mixer or into trucks or transit mixers. A master push-button control is provided to release the fine aggregate, the coarse aggregate and the cement as a dry mix. Release and discharge of the water are controlled independently. Discharge valves cannot be closed until they are completely emptied.

Lightweight Insulated Furnace Wall

THERE IS a definite demand for comparatively thin fire brick walls having several inches of applied insulation. A thin wall of regular firebrick at any ordinary height is not a thoroughly stable structure but stability is readily secured by using the sectionally supported principle of construction, such as is used in the familiar Detrick air-cooled wall.

The M. H. Detrick Co., 140 S. Dearborn St., Chicago, Ill., has developed a sectionally supported refractory wall in 12-in. thickness and the wall has found economic application for the side walls of boilers, alongside the tubes, and for enclosing water tube lined furnaces.

There is normally 9 in. of tile and 3 in. of insulation composing the 12-in. total thickness. The horizontal



THE NEW M. H. DETRICK CO., INSULATED WALL

supporting members of cast iron, and the vertical tile hangers also of cast iron, are located within this 12 in. of thickness. Vertical supporting steel columns, often referred to as buckstays, are located outside of the 12-in. thickness in order to keep them definitely in the cool.

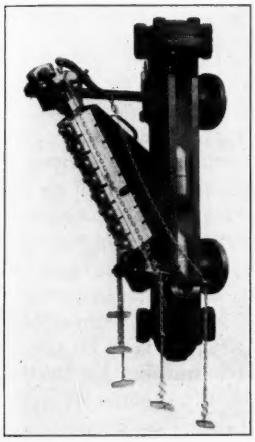
For both boiler construction and water tube furnace construction, one essential is that the assembly must be made entirely from the outside of the setting. In addition, the parts must be so arranged that workmen can readily do their work. In the illustration it will be noted that horizontal bars are located at wide vertical spacing (usually 30 in.), and that a row of vertical tile is used between the horizontally supported rows of tile. This construction is designed absolutely to lock every tile in position, conforming to the standard Detrick practice, and to provide ample room for the brick masons properly to do their work.

Detrick insulated sectionally supported wall has the primary advantage of light weight, as compared with a solid brick wall. It is air-tight, readily removable and replaceable, and occupies a minimum of the boiler room space.

Water Gage Without Glass

NEW TYPE OF WATER GAGE, good for any pressure, in which the water line is visible and which does not use glass, has been developed by the Reliance Gauge Column Co., Cleveland, Ohio. The drawing shows one of the gages, mounted in the inclined position on a Reliance forged steel high and low alarm column for 450 lb. pressure. An easily removable illuminator is shown at the back of the gage. The gage shown has a visible range of 12½ in. and the water line is distinct. It has also been made for pressures up to 1500 lb. and can be designed for much high pressures.

As shown in the sectional drawing Fig. 2, A is the



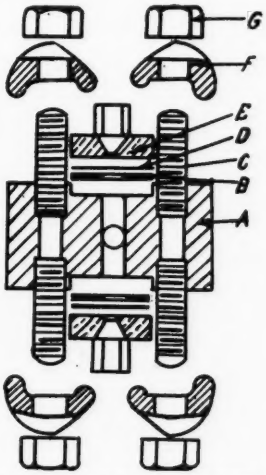


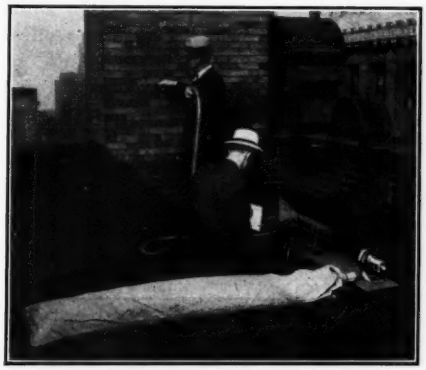
FIG. 1. NEW MICASIGHT GAGE IN INCLINED POSITION
FIG. 2. CROSS-SECTION OF MICASIGHT GAGE

forged steel housing with end connections to the shut-off valves. In the recesses on each side, an asbestos gasket B is placed having a slot through the center. Next strips of clear mica D are placed over the gaskets and a slotted clamping plate E holds the mica in place and makes the gasket tight by pressure from the clamps F and studs C. The clamps are so designed as to give a centralized pressure on the clamping plate, so that there will be no danger of warping the plate or necessity of pulling all studs up uniformly. The visibility is good, it is claimed, maintenance is simple and the mica has a long life and is immune to the action of high temperature distilled water or temperature strains, it is stated. This new gage will be marketed under the trade name of Micasight.

Bagtest Dust Sampler

BAGTEST DUST SAMPLER shown here has recently been developed for obtaining and testing samples of dust-laden gas. The equipment consists of a suitable nozzle for insertion in the gas stream, a fan driven by a 110-v. Universal motor and a bag into which the fan draws a sample of the gas to be tested.

It is designed to function within three per cent, plus or minus, of actual conditions. It can be applied to the flues in any part of the system or to the top of the stack if that is accessible. The testing set is designed to contain all the instruments necessary to determine accurately the dust loading of gases under varying conditions as found in power plants, steel mills, cement mills and the like. It is made to operate under minus pressures up to 15 in. of water and to handle gas volumes

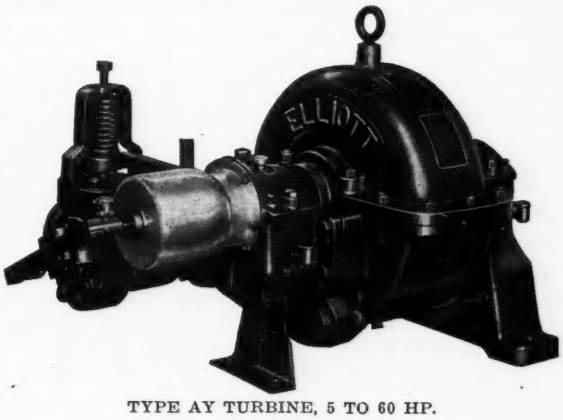


BAGTEST DUST SAMPLER IN USE

from 40 to 65 c.f.m. Each outfit is thoroughly tested before shipment and includes a complete set of instructions, with tables and calculations to permit rapid compilation of results. The sampler is a product of Dust Recovery, Inc., New York City.

Type AY Mechanical Drive Turbine

IMPROVED mechanical drive turbine is announced by Elliott Co., Jeannette, Pa. This machine incorporates in its design many features of larger turbines for generator drive, the maker states, such as horizontally split casing, steam and exhaust connections in lower half of casing, stiff shaft rotor—balanced both statically and dynamically, three-weight governor designed to eliminate all sliding friction, to insure quick response



TYPE AY TURBINE, 5 TO 60 HP.

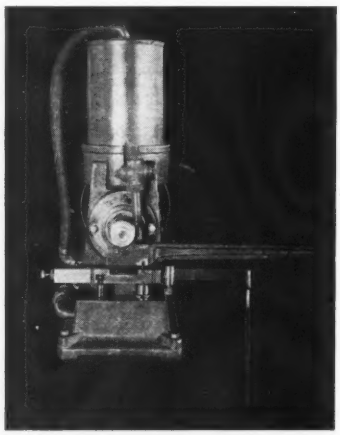
to load changes, emergency overspeed governor separate and distinct from the constant speed governor, each governor actuating its own valve, supports providing for both axial and lateral expansion.

This turbine, called the Type AY, is for a size range from 5 to 60 hp. When lagged and built with cast steel casing and steam chest, it is suitable for operation with 400 lb. steam pressure and 700 deg. temperature. It is a single-stage turbine, the rotor having either two or three bucket wheels depending upon conditions.

Lubricant Tester

FOR TESTING the load carrying capacity of lubricants, an apparatus has recently been developed for use in the laboratory of Timken Roller Bearing Co., Canton, Ohio, as a means for obtaining accurate information on the effect of different lubricants on Hypoid and spiral bevel gears in automotive axles and to test lubricants in connection with many intricate industrial bearing problems. The results obtained during the course of these tests were so valuable that it was decided to perfect the apparatus and place it on the market.

The apparatus consists essentially of a cast-iron base which supports the testing mandrel, two levers and a



DEVICE FOR TESTING LOAD CARRYING CAPACITY OF LUBRICANTS

container holding about a gallon of the lubricant to be tested. The mandrel is mounted in two Timken bearings, arranged to hold it rigidly in alinement and is tapered at the test end to receive the tapered cup of a Timken bearing. This cup, which forms one of the test pieces, is held in place firmly by a nut on the end of the mandrel, which is threaded to receive it.

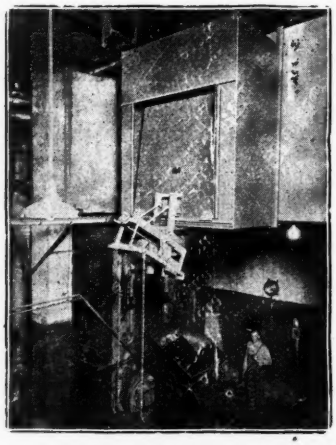
The lever system, the most important part of the device, consists of two levers, one above the other. The upper is called the load lever and the lower the friction lever, for reasons that will appear. The upper, which carries the test block, is pivoted on a knife edge, mounted in the lower lever. The latter is also pivoted on a knife edge and is provided with a stop at the unloaded end. By virtue of this arrangement the test block is always parallel to the revolving cup and the unit loading over the length of both pieces is always constant. The test block is a small piece of metal about ½ in. square by ¾-in. long, hardened to Rockwell C-60 and ground. It is inserted in a notch in the loading lever and held in place by a wedge.

The operation of the device is substantially as follows: Assuming both test pieces in place, the driving motor or line shaft is brought up to the desired speed and the lubricant, heated to the required temperature, is allowed to flow over the test block. The loading lever is then loaded by means of weights until the desired unit pressure is obtained between the test pieces. A chart is furnished with the apparatus which gives the necessary weights on the loading lever per 1000 lb. of unit pressure. If only the load carrying capacity of the oil is to be determined, the test block is removed after 30 min. running and examined for signs of scuffing. The degree of scuffing determines the relative load carrying capacity of the lubricant. In case the coefficient of friction of the lubricant is desired, weights are added to the friction lever until it moves away from the stop. Loading the upper lever causes the friction on the test block to move it forward horizontally, unbalancing the friction lever until it rests on the stop. This condition is compensated by adding the weights on the friction lever, until the system is again in balance and the lever is off the stop. The coefficient of friction of the lubricant is then calculated from the amount of weight it takes to balance the levers.

The Field Barometric Draft Control

VARYING DRAFT creates excess air conditions which have an unfavorable effect on proper fuel combustion and result in loss of plant efficiency. As a result; many attempts have been made to control the flow of air through the combustion chamber to an absolute constant. To secure absolute control of excess air, it is necessary that the draft regulator be not only automatic in operation but also capable of handling a wide range in draft fluctuations.

In actual test, it has been found a common occurrence for the intensity of the draft to vary 50 per cent or more in less than 5 min. It is unusual for the draft to remain the same for two or three hours at a time. The Field Barometric Draft Control automatically ad-



FIELD BAROMETRIC DRAFT CONTROL INSTALLED IN A POWER PLANT

justs itself to every change in draft and weather conditions, causing the fire to burn uniformly and eliminating the stack loss. It is adaptable to high and low-pressure plants and for hand or mechanical firing of coal or coke, gas or oil. With the patented arrangement of the weight mechanism, it is possible to bypass, automatically, sufficient excess air through the opening in the draft control, to maintain all times the desired draft in the combustion chamber.

The Field Barometric Draft Control is manufactured by an Illinois corporation, directed by E. A. Field, Sr., as president and is distributed by the Chicago Fuel Saver Co., Inc., 5510 Broadway, Chicago, Ill.

News Notes

TOTAL ELECTRICAL OUTPUT of 155,000,000 kw-hr. for May, 1931, has been reported by National Electric Power Co. and National Public Service Corp., eastern units in the Middle West Utilities System. This represents an increase of 16.1 per cent over May, 1930, when output totalled 133,600,000 kw-hr.

For the first five months of 1931, the National Group shows a total kw-hr. output of 816,000,000 kw-hr., a gain of 15.1 per cent over the same period a year ago. Output of the subsidiaries' power plants increased 20.6 per cent, while energy purchased from outside sources was reduced 16.2 per cent, reflecting several large additions to system generating capacity in the past twelve months. Total installed capacity, both steam and hydro, of National Electric Power Co. and National Public Service Corp. at June 1, 1931, was 773,000 kw. The figure represents an increase of 17 per cent over the installed capacity at the first of the year and 55 per cent over the installed capacity of 497,000 kw. at January 1, 1930.

This addition of over 275,000 kw. of capacity in less than a year and a half has been effected both through acquisition of properties and construction of new generating stations. Purchase of Eastern New Jersey Power Co. by National Public Service Corp. in May added to the National Group the new Sayreville steam station with a capacity of 60,000 kw. and other stations. Acquisition of the Columbus, Delaware, and Marion Electric Co. in December, 1930, added the Scioto steam plant at Marion, O., with 30,000 kw. capacity.

New generating stations constructed by subsidiary companies during the period include the 100,000 hp. hydroelectric station of Central Maine Power Co., at Bingham, Me.; the 50,000 kw. high-pressure steam station of Jersey Central Power & Light Co., at South Amboy, N. J.; and the 30,000-kw. steam station of Virginia Public Service Co., at Bremo Bluff, Va., which will be cut into service within the next few weeks.

Unique addition to the system's generating equipment is the floating power plant Jacona of the New England Public Service Co. This plant, a converted vessel of the U. S. Shipping Board with 20,000 kw. capacity, was placed in service last November at Bucksport, Me., to supplement the capacity of the Central Maine Power Co. It has since been moved to Portsmouth, N. H. where it is connected to the system of the Public Service Co. of New Hampshire.

OFFICERS of the Iowa Association of Power Engineers were elected at the closing session of the annual meeting in Ottumwa, May 29, as follows: John A. Murphy, Des Moines, president, succeeding B. E. Winger, Ottumwa, who was endorsed for national trustee; R. E. Tunnwall, Davenport, vice president; C. A. Bland, Des Moines, secretary, re-elected; C. H. Amos, Sioux City, treasurer, re-elected; A. E. Shoemaker, Ottumwa, conductor; and Lee Matson, Waterloo, doorkeeper. The association endorsed W. A. Pike, Marshalltown, for state deputy. Des Moines was selected for the 1932 meeting.

MCINTOSH & SEYMOUR CORP. is closing its Jacksonville, Florida, office and is moving it to 910 Seventeenth St. N. W., Washington, D. C.

BALDWIN LOCOMOTIVE WORKS purchased I. P. Morris & De La Vergne Co., Inc., of Philadelphia, Pa., on May 15 according to a recent announcement.

H. E. CHUBBUCK, former executive vice president in charge of the Illinois Traction System and other McKinley utilities interests in Illinois, died June 4 in his home, Grand View drive, Peoria, Ill., at the age of 68, after an illness of five months. Mr. Chubbuck was a grandson of Samuel Chubbuck and son of A. S. Chubbuck, pioneers in electrical development. He had been electrical expert for the Thompson-Houston Co. of Boston, from which the General Electric Co. developed. He was in charge of light plants in Pawtucket, R. I., Syracuse and Auburn, N. Y. and Springfield, Ohio; later reorganized the electric lighting system in Omaha and after the panic of 1893 reorganized the traction lines in Pueblo, Colo. After this assignment he became associated with the William B. McKinley interests, then launching into a middle western system, which supplied 100 communities in Illinois, Iowa, Nebraska and Missouri with electric light and operated 555 mi. of electric railways in Illinois. He came to Peoria in 1910 as general manager of the McKinley system, including the Illinois Traction Co., Western Railway and Light Co. and its various subsidiaries. Within a year he became vice president, a position he held until the Studebaker interests assumed control, eight years ago, when he retired from active business.

NORTHERN EQUIPMENT CO., Erie, Pa., announces the appointment of Joseph W. Eshelman as its representative in Eastern Tennessee. This is an extension of the territory formerly served by Mr. Eshelman from his offices in the Webb-Crawford Building, Birmingham, Ala.

LOS ANGELES OFFICE of the Kennedy Valve Manufacturing Co. has been removed to 706 Bendix Building, Los Angeles, Cal.

GEORGE F. NEWELL has been elected vice president and general manager of the Pyrometer Service and Supply Corp., Cleveland, Ohio, a subsidiary of the Claud S. Gordon Co., of Chicago. Mr. Newell was formerly the St. Louis representative of the Charles Engelhard Co. and more recently the Chicago representative of the same firm.

THE DAMPNEY CO. of America, Boston, Mass., announces that Murray G. Day, formerly superintendent of power of the New Bedford Gas and Edison Light Co. of New Bedford, Mass., has become associated with it. He will be attached to the Chicago Branch Office, 53 West Jackson Boulevard.

GORDON FOX and W. S. Orr, members of the engineering staff of the Freyn Engineering Co. arrived in the United States June 19 on the S. S. Vulcania. Mr. Fox and Mr. Orr have been in the U. S. S. R. for the past 10 mo. in connection with consultation services which Freyn Engineering Co. is rendering to the Soviet iron and steel industry.

COMPLETE SCHEDULE of national and district meetings of the American Institute of Electrical Engineers for the remainder of the calendar year 1931 and for the entire year 1932, is as follows:

1931

August 25-28	Annual Pacific Coast Convention	Lake Tahoe, Calif.
October 22-24	District Meeting	Kansas City, Mo.

1932

January 25-29	Annual Winter Convention	New York, N. Y.
March 14-16	District Meeting	Milwaukee, Wis.
May —	District Meeting	Providence, R. I.
June 20-24	Annual Summer Convention	Cleveland, Ohio
Aug. 29—Sept. 2	Annual Pacific Coast Convention	Vancouver, B. C.
October —	District Meeting	Baltimore, Md.
November —	District Meeting	Memphis, Tenn.

Book Reviews

WELDING OF WATER WHEELS is the subject of N.E.L.A. publication No. 116, a recent report of the Hydraulic Power Committee, National Electric Light Association, 420 Lexington Ave., New York City.

This report presents the results of an inquiry addressed to member companies and to organizations specializing in the application of welding to the repair of water wheels and their accessories. It discusses nature of repair work on water wheels, and methods used in repairing pitted wheels, or wheels damaged in service. Cast iron, bronze, and cast steel wheels are considered in this survey.

Welding repairs on shafts, guide vanes, draft tube liners and other parts are described and experience on the resistance of different materials to pitting, the enduring properties of repairs made by welding, and the value of welding processes in general with regard to problems of operation and maintenance are treated. Life of water wheels and the use of wheels of stainless steel and steel wheels built up by welding are next taken up. Other subjects are cost data for repair work of various kinds, gain of efficiency attributable to repairs, materials used in welding, trade names, and so on, comments of organizations engaged commercially in welding repair work as covered in this report.

MODERN DIESEL ENGINE PRACTICE, by Orville Adams; 656 pages, 400 illustrations; cloth, 6 by 9½ in.; Norman Henley Publishing Co., 2 West 45th St., New York City; price, $6.00.

The purpose of the author, a consulting Diesel engineer, in presenting this book is to combine in convenient, useful form reference data on construction and design of Diesel engines with a practical operator's manual. After some introductory chapters dealing with the evolution and general considerations of use of the Diesel engine, the discussion covers technical applications, selection, auxiliaries, plant requirements and so on. The following chapters are devoted to operation of engines, maintenance, lubrication and descriptions of typical engines. Under operation, we find discussion

of operation of 4-stroke cycle and 2-stroke cycle, of solid injection and air injection engines. Two chapters are given to engineering of a Diesel plant, discussing such factors as location of the plant, installation of piping, foundations, cooling water supply and its treatment, tanks and so on. A chapter is devoted to piston ring relation to lubrication and economy. Two chapters describe in detail the Packard Diesel aircraft engines and their operation and other chapters give detailed discussion of Diesel-powered railroad locomotive plants, construction and repair of these, fuel supply equipment and automotive application of Diesel engines.

SURFACE DECARBURIZATION of Steel at Heat-Treating Temperatures by W. E. Jominy. Published by the Department of Engineering Research, University of Michigan, Ann Arbor, Mich., as Engineering Research Bulletin No. 18. 50 pages, 6 by 9 in. Paper bound, price, $1.00.

Material in the bulletin is the result of an investigation sponsored and proposed by the American Gas Association. Decarburization of steel has been a source of considerable trouble in certain hardening operations in which the maximum surface hardness is required. This effect is obtained in most steel, although the action takes place much quicker in steels of certain composition. Conclusions, recommendations and results of a large number of tests are given in the bulletin.

MECHANICAL LABORATORY METHODS by Julian C. Smallwood and Frederic W. Keator. Published by D. Van Nostrand Co., Inc., 250 Fourth Avenue, New York, N. Y. Fourth edition, 331 pages, 6 by 9 in., cloth; price, $3.50.

A thorough revision and rearrangement of this popular book of testing of instruments and machines in the mechanical engineering laboratory and in practice with the old and obsolete material has been omitted. Practically all of the sections have been re-written and expanded to cover new developments and fourteen new tests have been added. Detailed treatment of thermodynamics, mechanics, and similar material readily obtainable in other words, as well as details of apparatus, readily understood by a physical examination or performance of the actual developments, have been left out. It is divided into four parts: Part 1 begins with the testing of instruments, such as calibration of gages, thermometers, brakes and indicators, Venturi and fluid meters; Part II, analysis of combustion, dealing with the determination of heat values; Part III, the testing of power plant units such as prime movers, steam boilers, auxiliary equipment, internal combustion engines and refrigerating machinery; Part IV, miscellaneous tests, lubricating oils, hygrometry and electrical machinery. Recent standards established by the A. S. M. E. have been followed and references given to this code when necessary or desirable. This book, really a testing hand book, should be valuable for the operating or test engineer.

ELEMENTS OF THERMODYNAMICS, by Ernest M. Fernald. Published by McGraw-Hill Book Co., Inc., 370 7th Avenue, New York, N. Y.; 297 pages, 6 by 9 in., cloth; price, $3.50.

Intended primarily as a text book for college students, this book does not meet the needs of the practicing engineer, as well as others which are already available, although there are three chapters that deserve special mention: Chapter 7, ideal steam cycles, Chapter 11, perfect gas cycles and Chapter 17, dealing with a number of miscellaneous items of interest to power station. These chapters cover the application of theoretical cycles to power generation, and discuss high pressure, reheat, extraction turbines and the mercury vapor cycle, all of course from the theoretical standpoint.

THE PSYCHOLOGY OF THE INVENTOR, by Joseph Rossman; 252 pages, cloth, 5½ by 8½ in. Inventors Publishing Co., Washington, D. C.; price, $3.00.

With a background of experience in the Patent Office, practicing lawyer, engineer and special study in psychology, the author has consulted with some 700 living prominent inventors as to their views and experience on the topics discussed. He deals with invention in its relation to humanity and human progress, why an inventor invents and how does he get that way, what the successful inventor must consider and the traits of mind conducive to invention.

The book is a study of inventors and methods of making inventions, not of the inventions themselves. It is of interest to those who are considering invention as an occupation and of some casual interest to the general reader. One valuable feature is a comprehensive bibliography of magazine articles and books which deal with invention, inventions and inventors, also with sociology and psychology as they relate to invention. The author's research has gathered facts not before available in print which he has presented clearly and interestingly. Reading the book will not make one an inventor but it should give him better understanding of the requisites for success.

Catalog Notes

COMPLETE DETAILS of the G. Harrison Smith, a new tanker of the Standard Shipping Co., are given in a bulletin just issued by the De Laval Steam Turbine Co., Trenton, N. J., builders of the turbines, gears and generating units with which the ship is equipped. Complete details are given on the boiler equipment which includes air preheaters and internal type desuperheater and full information is given regarding the De Laval steam turbines which drive a single screw through a double reduction gear. Westinghouse motors and generators and Foster Wheeler condensers for the main turbine are also installed. The bulletin contains complete details of the auxiliary equipment.

STURTEVANT UNIT VENTILATOR is described in a new 46-page illustrated catalog No. 377 by the B. F. Sturtevant Co., Hyde Park, Boston, Mass. The catalog describes the unit ventilator in great detail and discusses its operation, which is based on the partial recirculating principle so that when desired it can admit 50 per cent of outdoor air and recirculate 50 per cent of the indoor air. The object of this design, when the ventilator is used in schools and public buildings, is to obviate the necessity of opening windows and to dissipate objectionable odors.

CLEVELAND TRAMRAIL, manufactured by the Cleveland Crane & Engineering Co., Wickliffe, O., with raised tread for the trolley wheels, is described in a leaflet recently issued.

VIKING hydraulic pumps and motor-driven units are described in a leaflet issued by Viking Pump Co., Cedar Falls, Iowa.

MERCURY COLUMN gage for low pressure and vacuum with glass and scale and 3-way connection is described in a circular from Amthor Testing Inst. Co., Inc., 309 Johnson St., Brooklyn, N. Y.

REASONS for learning Esperanto, the international language which has no idioms or exceptions to its rules and which is used in 2000 cities of 70 countries, are given in a folder available free by request to the National Secretary, Universal Esperanto Assn., 109 Fordham Drive, Buffalo, N. Y.

HAMMEL POLES made of steel in various types are described in a recent illustrated 8-page catalog No. 1-A issued by the Pole Division of the Pittsburgh Crucible Steel Co., Pittsburgh, Pa. This describes and illustrates the Hammel Pole, its adaptability to lighting standard and wiring carrier requirements and shows the various ways in which it has been used.

FARM WATER POWER is the subject of Farmers bulletin No. 1658 recently issued by the United States Department of Agriculture and obtainable from the Superintendent of Documents, Government Printing Office, Washington, D. C., price 10 cents. This bulletin prepared by George M. Warren, Associate Hydraulic Engineer, Division of Agricultural Engineering, Bureau of Public Roads, discusses typical farm plant, use and care of plants, water supply, power estimates, dams and storage, choice of wheels, headrace and tailrace design, trash racks, governors, wiring, manufacturers' helps, and department helps.

YOUNG UNIT HEATERS are described in a recent 16-page illustrated bulletin issued by Young Radiator Co., Racine, Wis. These heaters are designed for application to industrial buildings, stores, large offices, etc. They are made in various models, ranging from equivalent radiator capacity of 196 sq. ft. up to about 3000 sq. ft. each, depending upon the steam pressure and the conditions. The heat transfer core or condenser of the unit is composed of flat copper tubes 3/16 in. wide, set in line and fitted with flat copper fins. Upper and lower reservoirs or tanks are of close grained motor block quality nickel cast iron, ribbed and formed for great strength and high pressure. Motors are especially designed and may be furnished in ball-bearing or sleeve-bearing type, single or multi-speed as desired. The fans or propeller blades used on this unit are designed to give the greatest capacity with low power consumption. Tubes and fins over the entire core, inside and out, are coated with a heat and corrosion resisting alloy. The units are made in single and double types with approximate air delivery ranging between 500 c.f.m. and 10,000 c.f.m.

SPRAY NOZZLES are completely described and illustrated, with tables and charts of capacities and illustrations and discussion of application of these nozzles, in a new 32-page bulletin, illustrated in colors, by Schutte & Koerting Co., Philadelphia, Pa. This bulletin, No. 6-A, replaces the former 6-A and 6-C sections of the S&K catalog on jets. Application of these nozzles to the washing of solids from gases, absorption of gases, cooling and refrigerating, coating processes, spraying water and other power plant and industrial operations are discussed and illustrated in considerable detail.

CHARTS taken from combustion control systems, steam pressure recorders and other instruments are included in a 12-page bulletin of Brooke Engineering Co., Inc., 3640 N. Lawrence St., Philadelphia, Pa., to show the action of Brooke electrically actuated pressure control equipment.

OIL PUMPS, horizontal duplex type, piston pattern, high pressure, type S.P. are described and illustrated, with tables of capacities and sizes, in a recent bulletin W-112-S10, published by Worthington Pump & Machinery Corp., 2 Park Ave., New York City. This company has also published bulletin D-423-E8 on power pumps, vertical triplex, single acting type. Hot oil pumps, horizontal duplex, piston-pattern, heavy-pressure type S.P. are described in bulletin W-112-S11 and Worthington patented, folded-tube, layer-type surface condenser in W-200-S-10, superseding W-250-S3.

RUG-KLING FLASHES on modern equipment, just issued by Ruggles-Klingemann Mfg. Co., 38 Chauncy St., Boston, Mass., describes and illustrates in detail pressure regulating and control equipment devices manufactured by this company.

IN AN INTERESTING booklet entitled What Is the Difference, Sterling Engine Co., 1270 Niagara St., Buffalo, N. Y., shows by illustration and description the features which differentiate between the high-duty gasoline engine for power standby service and the "industrial engine." Points discussed are design to take care of stresses, free distribution and flow of fuel charge, cooling and testing. Examples of a wide variety of applications are shown.

LINK-BELT CO., Indianapolis, Ind., has just issued an illustrated book, No. 1293, which describes silent and roller chain, herringbone gears and speed reducers, worm gear speed reducers, steel and malleable chains, P.I.V. positive variable speed transmission. Many illustrations of installations are shown, with accompanying descriptions. Copies are available on request.

BULLETIN 40-I, which gives complete and detailed information concerning Fairfield Portable Belt Conveyors in sizes from 20 to 60 ft. for handling a wide variety of materials including sand, gravel, crushed stone, mixed concrete, steel scrap, grain, agricultural limestone and cinders, has been issued by Fairfield Engineering Co., Marion, Ohio. Other materials are handled successfully with certain limitations, including coal and coke for storing and reloading. The conveyors are furnished with belt widths of 20 in. and 24 in. and can be equipped with electric or gasoline power units as preferred.

NEW SINGLE-STAGE mechanical-drive turbine built in sizes from 5 to 60 hp. is described in a new 4-page bulletin just issued by Elliott Co., Jeannette, Pa. This turbine, known as the type AY Mechanical Drive Turbine, when lagged and built with cast steel casing and steam chest, is designed for operation with 400 lb. steam pressure and 700 deg. temperature. The features of the turbine are completely described and illustrated with photographs and drawings of the various parts.

LINDAHL LINE of pulleys and sheaves is completely described and illustrated with tables of dimensions, weights, price lists and engineering data in a 64-page catalog, No. 24, just issued by Henry Lindahl Foundry & Machine Co., 5900 Ogden Ave., Chicago, Ill.

GRINDING AND HEAT TREATMENT as causes of cracks in hardened steel is the subject of a recent 20-page illustrated bulletin issued by Norton Co., Worcester, Mass.

DIEFORM COMPRESSION FITTINGS are described in a new bulletin No. 13, now being distributed by the Bailey Meter Co., Cleveland, Ohio. This describes the application, advantages and installation of Dieform Compression Fittings when used with copper or steel tubing for small service lines. The material is recommended for piping where many bends must be made and where an absolutely tight, neat appearing, trouble free installation is required. It is especially suitable for high pressure and high temperature service such as connections to metering equipment and water, oil, steam, compressed air and gas lines.

KEEPING PACE WITH MACHINE DESIGN is the title of a new booklet just published by Cutler-Hammer, Inc., 295 N. 12th St., Milwaukee, Wis. The booklet details the construction, operation and application of C-H Magnetic Clutches, including a full description of the newly developed C-H Duplex Clutch. Many installation photographs show magnetic clutches applied to various types of machines with schematic diagrams to demonstrate the action of the clutches.

BROADSIDE describing and illustrating its new indicating control instrument for automatically controlling relatively high temperature processes and units such as heat treating furnaces, enameling furnaces, oil stills and towers, brick and pottery kilns, glass furnaces, galvanizing tanks, has been published by the Brown Instrument Co., Philadelphia, Pa.

HIGHLY PRACTICAL INSTRUCTIONS for the care and operation of transformers are given in a booklet just issued by the National Electrical Manufacturers Association. This is the fifth edition of this work and it has been carefully revised and edited so as to contain the latest available information. It will be found extremely useful by electrical engineers, distribution superintendents, line foremen, electricians, operators, electrical students and all other persons responsible for the safe operation and the maintenance of transformers.

The contents treat among other things of location, handling, inspection and storage of transformers. Drying coils and cores, sampling, testing and drying oil, and filling transformers are important items described.

This handbook represents the recommendations of the Trans former Section of the National Electrical Manufacturers Associa tion, the member companies of which Section produce the great preponderance of distribution and power transformers in the United States.

The title of the booklet is "Instructions for Care and Operation of Transformers," revised April, 1931, and it supersedes the fourth edition of April, 1926.

Copies may be purchased at $.25 each from the National Electrical Manufacturers Association, 420 Lexington Ave., New York City.

IF, AS HAS BEEN PROVED, the presence of certain gases in the furnace is harmful to an enamel during the burning process, it appeared reasonable to assume that their presence might also be deleterious to the enamel during smelting. With this thought in mind the work, the results of which are published in Bulletin No. 224 of the Engineering Experiment Station of the University of Illinois, was designed to make a preliminary study of some of the gases evolved in the smelting of enamels for sheet steel, and to determine the effect of certain smelter atmospheres on the quality of the enamels. Copies of Bulletin No. 224 may be obtained without charge by addressing the Engineering Experiment Station, Urbana, Ill.

IXL HYGRADE worm reducers are discussed in the new 84-page catalog No. 301, issued by Foote Bros. Gear & Machine Co., 215 N. Curtis St., Chicago, Ill. The book opens with a detailed technical discussion of the evolution of worm gearing, showing how various factors such as automotive work, industrial developments, research, design, material, manufacture and so on have influenced the development. A particularly interesting part of the discussion is the chapter entitled "The Customer's Problem," giving information on design manufacturing methods, materials and selection of units as well as new data on efficiencies. Many tables of ratios and ratings for hygrade worm gear speed reducers are given with dimension drawings, typical lay-outs and detailed information on the construction of these reducers.

RESEARCH SERVICE FOR INDUSTRY, is the title of Engineering Research Circular No. 5, published by the Department of Engineering Research of the University of Michigan, Ann Arbor, Mich. This department was established so that the facilities and personnel of the University could be made available for research activity in the interest of industry and the circular describes the facilities, presents information on the research service and the conditions under which it is available.

Personnel and facilities of the laboratories are available for investigation sponsored by organizations or by individuals not connected with the University. The sponsor secures the service by paying the expenses of the investigation, these expenses usually include direct and supervisory labor, materials consumed in the investigation, special equipment which it may be necessary to purchase, transportation of materials, communication and traveling expenses, special equipment installation and maintenance, reports, and a service charge based on the cost of labor. When the investigation develops something of a patentable nature, the sponsor is advised so that he can decide whether he is interested in having an application made for a patent.

IN CONNECTION with the activities of nomenclature of non-ferrous metals and alloys, Committee B-2 on Non-Ferrous Metals and Alloys of the American Society for Testing Materials has just issued a revision of its 1922 publication entitled, A List of and Physical Properties of Typical Alloys. This is a 65-page booklet published by the American Society for Testing Materials, Philadelphia, Pa., and available in two bindings; paper at $1.50 per copy, and cloth at $2.00 per copy.

This work was prepared by William Campbell and lists more than 2500 alloys. While the list is primarily one of non-ferrous alloys, there are included examples of what are, properly speaking, iron alloys (in contra-distinction to steel) in which the properties are dependent on the added elements. Several of these are found in the lists of non-corrosive and heat-resisting alloys.

Power Plant Construction News

Ark., Fort Smith—The Banfield Brothers Packing Co., Tulsa, Okla., is said to be planning installation of electric power equipment in proposed new meat-packing plant at Fort Smith, entire project to cost about $90,000.

Calif., Beverly Hills—The Southern California Edison Co., Ltd., Los Angeles, is planning a substation expansion program in the Beverly Hills district to cost about $150,000 with equipment. Company engineering department is in charge.

D. C., Washington—The Potomac Electric Power Co., Tenth and East Streets, N. W., has filed plans for a power substation on First Street, near T Street, reported to cost more than $45,000, with equipment.

Fla., Pensacola—The Weiss-Patterson Lumber Co., Pensacola, plans installation of motors and other electric power equipment in connection with proposed rebuilding of portion of mill recently destroyed by fire with total loss reported in excess of $100,000.

Ga., Atlanta—The Gaylord Container Co., 229 Grant Street, S. E., plans installation of electric power equipment in proposed new one-story paper container manufacturing plant, 200 x 220 ft., entire project reported to cost more than $80,000.

Ga., Valdosta—The City Council is said to be planning the installation of pumping machinery in connection with extensions and improvements in municipal water works. An appropriation of about $25,000, is being arranged.

Ill., Chicago—The Edward Katzinger Co., 1949 North Cicero Avenue, plans installation of electric power equipment in connection with new addition to tinware manufacturing plant, entire project to cost over $100,000. A. G. Alschuler, Steger Building, Chicago, is engineer.

Ill., Streator—The Streator Clay Co. is said to be planning the installation of electric power equipment in connection with proposed rebuilding of portion of plant, recently destroyed by fire with loss reported over $125,000.

Ind., Seymour—The Blish Milling Co., Seymour, is said to be planning the installation of electric power equipment in connection with a new addition to local flour mill, entire project to cost over $100,000.

Ind., South Bend—The Board of Trustees, Notre Dame University, South Bend, has plans for an addition to power plant, reported to cost over $70,000, with equipment. Albert Kahn, Marquette Building, Detroit, Mich., is engineer.

Iowa, Tama—The Iowa Railway & Light Co., Cedar Rapids, Iowa, is said to be planning the installation of an artificil gas distributing plant at Tama, reported to cost about $65,000.

Ky., Louisville—The Hillerich & Bradsby Co., Louisville, plans installation of electric power equipment in proposed rebuilding of portion of woodworking plant, specializing in production of baseball bats, golf clubs, etc., recently destroyed by fire with loss reported in excess of $250,000.

Mich., Bay City—The City Council plans installation of pumping machinery in connection with extensions and improvements in municipal sewage plant, entire project reported to cost over $200,000. Menefee & Dodge, Ann Arbor, Mich., are engineers.

Mich., Gladstone—The Ford Motor Co., Highland Park, Mich., plans installation of electric power equipment in connection with a proposed new foundry and other industrial structures on site recently acquired at Gladstone, entire project reported to cost more than $250,000.

Miss., Hattiesburg—It has been reported that the State Teachers College is making preliminary tentative plans for a new power plant. It has not yet been decided whether this will be a steam or diesel engine plant but it is expected that it will be in operation by March 1932 and the probable cost will be in the neighborhood of $60,000.

N. C., Penland—The Carolina China Clay Co., care of W. F. Deneen, head of the North State Feldspar Co., Micaville, N. C., recently organized by Mr. Deneen and associates, plans installation of electric motors, pumping machinery, steam dryers and other mechanical equipment, in connection with a proposed clay mining plant at Penland, entire project to cost over $75,000.

N. C., West Jefferson—The Northwestern North Carolina Utilities, Inc., operated by the Empire Public Service Corporation, 1600 Arch Street, Philadelphia, Pa., is said to have preliminary plans under way for a hydroelectric generating plant at Sharpes Falls, on the New River, near West Jefferson, to cost over $250,000, with transmission lines.

N. D., Fort Yates—The Northern Power & Light Co., Selfridge, N. D., is planning the construction of a new transmission line from Selfridge to Fort Yates, about 16 miles, with power substation, reported to cost over $50,000.

Ohio, Cleveland—The Addressograph-Multigraph Corporation, 1814 East Fortieth Street, has authorized the construction of a one-story steam power house, in connection with proposed new plant on Babbitt Road, Euclid district, with installation to include two 325 h.p. watertube boilers, pumping machinery, feed-water regulators, ash and coal conveying system and other mechanical equipment. Ernest McGeorge, Inc., 3030 Euclid Avenue, Cleveland, is consulting engineer.

Ohio, Massillon—The Ohio Water Service Co., Massillon, has authorized the immediate construction of a new local water softening and treating plant to cost about $175,000, with equipment.

Pa., Philadelphia—The Pennsylvania Sugar Co., Delaware Avenue and Shackamaxon Street, has plans for a multi-story boiler plant at local refinery, 70x74 feet, estimated to cost about $70,000 with equipment. A building permit has been issued.

Pa., Philadelphia—The Philadelphia Electric Co., Tenth and Chestnut Streets, has acquired property at Tenth and West Moreland Streets, 91x158 feet, as a site for a new power substation for which plans will soon be drawn. It is reported to cost over $75,000, with equipment. Company engineering department is in charge.

Pa., Sharpsburg—The Borough Council has engaged Barton R. Shover, Oliver Building, Pittsburgh, Pa., consulting engineer, to make investigations and prepare plans for extensions and improvements in municipal electric light and power system.

Pa., Williamsport—The Pennsylvania Power & Light Co., Allentown, Pa., plans installation of compressor plants in connection with a proposed natural gas pipe line from oil fields in Tioga County to Williamsport and vicinity. Estimated cost not announced.

S. C., Greenville—The Brooks Brothers Co., 4841 Lancaster Avenue, Philadelphia, Pa., plans installation of electric power equipment in proposed new tapestry mill, 90x100 feet, at Greenville, entire project reported to cost over $65,000.

Tenn., Chattanooga—The City Water Co. plans installation of pumping machinery and auxiliary equipment in connection with extensions and improvements in waterworks in the North Chattanooga and Berkeley Hills districts. A fund of $25,000, will be expended.

Tenn., Memphis—The Memphis Natural Gas Co., Memphis, plans installation of compressor plants and other mechanical equipment, in connection with a new natural gas pipe line from Memphis to Jackson, Tenn., about 100 miles, entire project to cost over $400,000.

Texas, Corsicana—The Magnolia Petroleum Co., Dallas, Texas, plans installation of pumping machinery and other mechanical equipment in connection with a proposed new pipe line for oil service from Kilgore to Corsicana, entire project reported to cost over $200,000.

Texas, Fort Worth—The Sinclair Refining Co., 45 Nassau Street, New York, plans installation of electric power equipment in connection with extensions and improvements in the former refining plant of the Pierce Oil Co., Fort Worth, recently acquired, entire project to cost more than $1,000,000.

W. Va., Martinsburg—The Water Commission is said to be planning the installation of pumping machinery and auxiliary mechanical equipment in connection with extensions and improvements in municipal waterworks, entire project to cost about $100,000.

Wis., Bangor—The Village Council has preliminary plans under way for a new electric light and power system, reported to cost about $25,000. G. M. Orr Co., Baker Building, Minneapolis, Minn., is engineer.